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Guidelines for Preparing and Reviewing Feasibility Studies

Index Systems, Inc, Cambridge, Mass

Prepared for

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GUIDELINES FOR PREPARING AND REVIEWING FEASIBILITY STUDIES

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Tjis report presents guidelines for preparing and reviewing the first of the four phases of an ADP project, the feasibility study. The report is divided into three chapters associated with the production and review of ADP feasibility studies, as follows: Chapter I discusses the purpose of a feasibility study, the organization of the feasibility study report, and the procedures to be followed in performing a feasibility study; Chapter II presents the nine major tasks in performing the study; and Chapter III presents guidelines and checklists for reviewing and evaluating a feasibility study.

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I. INTRODUCTION

This report presents guidelines for preparing and reviewing the first of the four phases of an ADP project, the feasibility study. The remainder of an ADP project consists of three additional phases, as follows:

- System Design Specifications
- Program design, Programming and Testing
- System installation, Conversion and Operation

This report is divided into three chapters associated with the production and review of ADP feasibility studies, as follows:

- Chapter I discusses the purpose of a feasibility study, the organization of the feasibility study report, and the procedures to be followed in performing a feasibility study.
- Chapter II presents the nine major tasks in performing the study
- Chapter III presents guidelines and checklists for reviewing and evaluating a feasibility study

1. THE PURPOSE OF A FEASIBILITY STUDY IS TO PERFORM DETAILED ANALYSES IN ORDER TO RECOMMEND A SOLUTION TO A PERCEIVED AGENCY INFORMATION NEED.

The feasibility study is an integral part of the overall planning effort, and is designed to achieve five management objectives, as follows:

- To assure that the data processing programs of the Agency are in accord with the Agency's plans and objectives and to assure their conformance to policy guidelines issued by the Agency, Office of Management and Budget, General Services Administration, National Bureau of Standards, and other external organizations
- To establish priorities of systems planning efforts when dictated by limited resources of time, talent, and funds
- To foster the clear definition of requirements, and the consideration of cost-effective alternative solutions for meeting these requirements
- To foster the sharing of ADP equipment and software systems
- To provide a basis for developing a coordinated information systems effort

The result of a feasibility study is a recommendation to management on whether or not to proceed with a specific ADP project. Within EPA a decision on whether or not to use ADP equipment is based on a documented feasibility study which sets forth those considerations essential to making a sound decision on the question. At EPA, these considerations revolve around three basic issues, as follows:

- The establishment of a clear, comprehensive and current definition and justification for system requirements
- An analysis of several feasible alternative approaches to satisfy the requirement, such as manual, semi-automated or fully automated systems
- A cost/benefit and cash/flow analysis of feasible alternative methods

2. THE NEED FOR A FEASIBILITY STUDY DEPENDS UPON THE ANTICIPATED TYPE AND COST OF THE ADP PROJECT

Feasibility studies are required for major new ADP systems or equipment. However, this requirement can be waived if the ADP project cost is under certain levels.

(1) Feasibility Studies Are Required for Three Types of ADP Activities

The preparation of a feasibility study applies to three types of ADP activities, as follows:

- Procurement of software packages
- Development of new information or data systems, or modifications to existing systems whether they are performed in-house, or by a contractor, or under any other contractual or interagency agreement
- Procurement of ADP equipment (ADPE) components. ADPE includes general purpose, commerically available, mass produced, automatic data processing components and the equipment systems created from them, regardless of use, size, capacity, or price, that are designed to be applied to the solution or processing of a variety of problems or applications and are not specifically designed (not configured) for any specific application. ADPE specifically does not include nonprogrammable desk calculators or word processing equipment that do not have a telecommunications capability.

(2) The Requirement for A Feasibility Study May Be Waived Depending on the Estimated Average Annual Cost of the Proposed System

The steps of an ADP system development cycle include the feasibility study, system design, system development, and system installation and operation. The impact of these steps and the associated documentation requirements are a function of the estimated average annual cost over the life of the system. The average annual cost is the total cost incurred by an ADP System divided by the expected number of service years. The total cost should include all direct procurement expenses as well as associated EPA personnel and computer resources and maintenance costs incurred in both developmental and operational stages. The estimated system life used to determine annual average cost should not exceed three (3) years unless specific justification is provided.

EPA defines three ranges of average annual costs for deciding whether a feasibility study is optional, at the discretion of MIDSD, or mandatory, as follows:

- Average Annual Costs Up To $20,000. The steps in the ADP Cycle may be combined and/or performed at the originator's discretion for systems valued at $20,000 or less. For example, the system may have its feasibility study and systems design combined in one step.

- Average Annual Cost From $20,000 to $100,000. In this case the steps in the ADP cycle may be combined if approved by MIDSD.
- Average Annual Cost in Excess of $100,000. In this case a feasibility study is mandatory and the steps in the ADP Cycle must be performed separately. Exhibit 1-1 on the following page summarizes the effect of monetary constraints on the preparation of a feasibility study.

3. THE FINDINGS AND RECOMMENDATIONS OF THE FEASIBILITY STUDY SHOULD BE DOCUMENTED IN A REPORT FOR REVIEW BY MANAGEMENT.

A feasibility study encompasses a thorough requirements analysis and an evaluation of alternative solutions in terms of costs and benefits. Adequate documentation for these studies is required to achieve four management objectives, as follows:

- Assure that a proper study has been performed in conformance with Government-wide standards and Agency-wide guidelines
- Provide a basis for reviewing officials to evaluate the proposal and the probable impact of the resulting decision
- Provide a benchmark for the future evaluation of the implemented system in terms of the original expectations
- Determine whether the functions for which ADP are to be used are essential and readily adaptable to automation

Exhibit 1-1

U.S. ENVIRONMENTAL PROTECTION AGENCY
The Effect of Monetary Constraints On Performing a Feasibility Study

Estimated Average Annual Cost	May Steps be Combined	Approval for Documentation	Estimated MIDSD Review Times
Up to $20,000	At originator's discretion	Originator	Less than 5 days
$20,000 - $100,000	With MIDSD's approval	MIDSD	Less than 5 days
$100,000 and up	No	MIDSD	Less than 5 days per step

There are six major sections of the feasibility study report, as follows:

- Management summary
- Needs analysis and evaluation criteria
- Feasible alternative systems
- Evaluation of alternatives
- Recommendations and next steps
- Appendices, as necessary

(1) The Management Summary Conveys the Main Findings of the Report.

This section presents the main findings and recommendations to management, along with a summary of the supporting analyses. Five areas are covered, as follows:

- An overview of the needs analysis
- An overview of current systems and the justification for a new system
- Feasible alternative solutions that were investigated
- A summary of the analysis of alternatives and the final recommendation
- A brief discussion of next steps

(2) Section 2 Presents the Needs Analysis and the Evaluation Criteria.

This section summarizes the justification for a proposed system, based on the analysis of program needs including legislative, policy, regulatory or timing requirements. In addition, the analysis of the inadequacies of current information systems is included.

The criteria for evaluating system alternatives are summarized based on the needs analysis. Evaluation criteria are benchmarks against which each alternative will be measured to determine its relative merit. The functional, technical and economic criteria are identified, weighted, and described.

(3) Section 3 Contains a Description of Feasible Alternative Systems.

There may be several feasible alternative systems which satisfy the end product and timing requirements, including manual, semi-automated and automated systems. Alternatives can range from simple clerical systems to very sophisticated automated processes. The description for each alternative usually will cover three areas, as follows:

- A general concept description
- Major features of the alternative
- The benefits and savings for each alternative

(4) Section 4 Presents the Evaluation of Alternatives.

This section presents the advantages and disadvantages of each alternative as measured against the evaluation criteria. Charts and tables are used to display the relative merits of alternatives in a fashion that allows for easy comparison.Potential annual benefits, annual operating expenses, and one-time development expenses are calculated for each proposal, with a cumulative cash flow analysis displaying the timing and amounts of both savings and expenses.

(5) Section 5 Contains the Recommendation and a Project Plan.

In this section the recommendation, its impact, and a project plan are presented in four sections, as follows:

- The system diagram for the recommended alternative

- A summary of the justification for the recommendation
- A summary of the detailed economic analysis for the recommended alternative
- The key milestones in the project plan for the design and implementation of the recommended system

(6) Appendices Are Included in the Report as Necessary.

Appendices are used to present the detailed analysis that supports the information in the body of the report. Seven examples of Appendices in a feasibility study report include:

- Detailed information supporting the needs analysis
- Detailed descriptions of the alternative systems solutions
- Details of the preliminary calculation of development and operating costs
- Cash flow analysis for each alternative
- Detailed system design for the recommended alternative
- Detailed economic analyses and cash flow analyses for the recommended alternative
- The project plan, milestones and schedules for the remainder of the project for the recommended alternative

4. STANDARD EPA PROCEDURES SHOULD BE FOLLOWED IN PREPARING A FEASIBILITY STUDY

For those projects which require a separate feasibility study, EPA has identified eight steps to be performed, as follows:

- Originators of systems proposals shall prepare a feasibility study report in accordance with guidelines presented in this document.
- The originator shall obtain all necessary internal program approvals and funding commitments.
- The originator shall prepare an Information Systems Resume, EPA Form 2800-2. The preparation of an Information Systems Resume is not required for proposals which involve only the acquisition of ADP equipment.
- The originating office shall submit two copies of the feasibility study and Information Systems Resume to the Management Information and Data Systems Division (MIDSD) for review of their ADP technical content.
- MIDSD shall provide the originating office with a written approval/disapproval of the ADP technical content of the feasibility study not later than five working days after receipt.
- Upon approval of the feasibility study, MIDSD will assign a System Identification Directory Number (SIDN) code to the proposed system and will inform the originating office of the SIDN. MIDSD will enter the information contained in the Information System Resume into the Information Systems Directory file.
- All subsequent requests for access to ADP resources in support of development of operation of the proposed system will require specific reference to the SIDN code assigned by MIDSD. The purpose of this requirement is to assure adequate tracking, recording, and consideration of costs.

- After approval of the feasibility study and assignment of an SIDN code, the originating office may proceed to design the proposed system.

II. GUIDELINES FOR PERFORMING A FEASIBILITY STUDY

A feasibility study should provide management with the information necessary for evaluating a variety of alternative systems solutions. The key elements of information needed to make such a decision can be obtained and presented by performing nine major tasks, as follows:

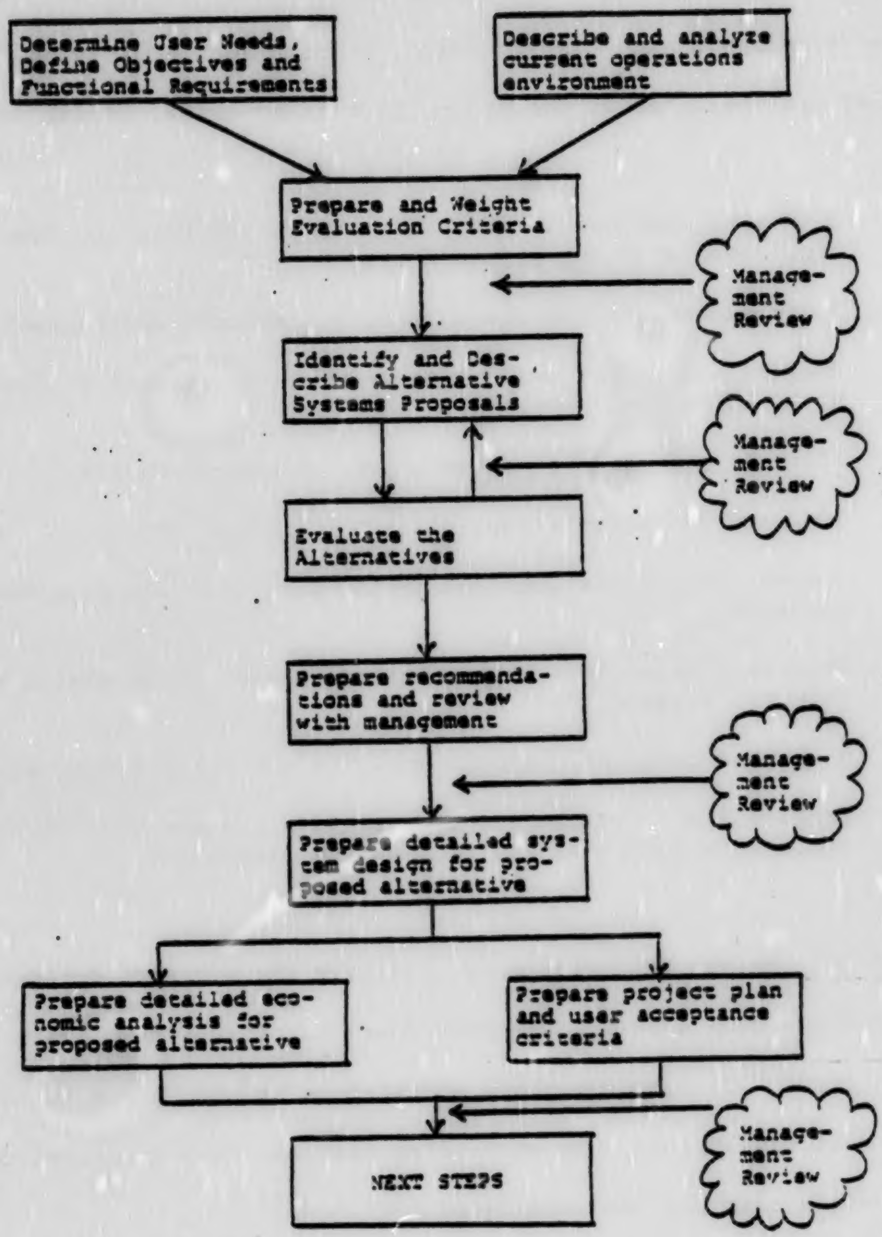
- Determine user needs, and define the objectives and functional requirements of the proposed system
- Describe and analyze the current operational environment
- Prepare and weight evaluation criteria to be used in evaluating alternative system solutions
- Identify and describe alternative systems proposals
- Evaluate the alternatives
- Prepare recommendations and review with user and management personnel
- Prepare a detailed system description and system design for the proposed alternative
- Prepare a detailed economic analysis for the proposed alternative
- Prepare user acceptance criteria and a project plan for the proposed alternative and review with management

Exhibit 2-1, on the following page, displays the sequence for performing each of these nine tasks. Note that there is often some iteration between tasks. In many cases the distinction between tasks is not as sharp as it may appear. The succeeding task may have commenced before the previous task has been completed.

Exhibit 2-1

U.S. ENVIRONMENTAL PROTECTION AGENCY

Sequence of Tasks in Performing a Feasibility Study


Determine User Needs, Define Objectives and Functional Requirements
Describe and analyze current operations environment
Prepare and Weight Evaluation Criteria
Management Review
Identify and Describe Alternative Systems Proposals
Management Review
Evaluate the Alternatives
Prepare recommendations and review with management
Management Review
Prepare detailed system design for proposed alternative
Prepare detailed economic analysis for proposed alternative
Prepare project plan and user acceptance criteria
Management Review
NEXT STEPS

The remainder of this Chapter describes the detailed steps within each of these nine tasks.

1. DETERMINE USER NEEDS, AND DEFINE THE OBJECTIVES AND FUNCTIONAL REQUIREMENTS OF THE PROPOSED SYSTEM

The first task in performing a feasibility study consists of defining a consolidated statement of user needs and objectives which justify the investigation of alternative solutions. There are five major steps in performing this task, as follows:

- Describe the current or proposed program environment
- Describe the major objectives for which a new system is required
- Define and rank user needs in priority order
- Define and rank major outputs from the proposed system in priority order
- Develop a consolidated statement of user needs, project objectives, and acceptance criteria for review with management

(1) Describe the Current or Proposed Program Environment

The purpose of this step is to provide an overview of the major functions of the program office for whom the feasibility study is being performed, and to define the environmental objectives and activities that these functions support. The overall program objectives must be understood before a comprehensive needs analysis can be performed.

The description should discuss the primary responsibilities of the program office, including its major activities and how these activities support the program strategy. The major relevant legislation, principal geographic locations, type and size of staff, and major computer systems and their functions also should be described.

In addition to defining the program's objectives, responsibilities, and activities, it is important to define the relevant organizational structure including interfaces with groups inside and outside the Agency. The organizational structure will indicate those areas where the proposed system may influence the activities of more than one group. In some cases, several offices may be responsible for different components of a system, and hence the successful operation of the system will depend on their mutual cooperation. If possible, the quality, experience and attitudes of the staff also should be described, as these may become critical factors in defining the acceptability of alternative proposals.

The principal geographic locations and physical layout of the office also should be described. This will be helpful in analyzing the feasibility of using time-sharing, communication links, or minicomputers, as well as distributed processing and data sharing concepts. The physical layout of the office within a given building or buildings should be described, using diagrams where possible, as this is helpful in defining the physical environment in which the proposed system will have to operate.

The major output of this step is detailed documentation discussing the program environment that the new system will have to support.

(2) Define Any New Legislative, Regulatory, Security, Timing or Other Requirements for Which a New System Is Required

At least four factors can generate a need for ADP support, as follows:

- New legislative requirements, or new internally established Agency direction, may require maintaining new information or data bases. These requirements should be clearly documented.
- The present workload may have increased to a point where it is no longer feasible to maintain current

manual or automated procedures. In this case, the reason for the increase and any growth projections should be given.

- Current systems may be providing inadequate service, such as slow turnaround time or a low degree of accuracy. The areas which require improvement should be documented.
- Managers may determine that certain manual procedures could be replaced more effectively by automated equipment. Here it may be useful to investigate whether other departments or government agencies have already addressed the same problem.

In defining a new requirement, describe the current and future scope of the need, including affected groups. A description should be provided of how the need is satisfied currently, because this will indicate how the need will be met until a replacement system becomes operational. For every new requirement, an attempt should be made to define the cost or impact of not meeting the need.

The major output of this step is a detailed description of the set of problems or new conditions which provide the justification and the driving force for investigating alternative systems solutions.

(3) Define and Rank User Needs and Requirements in Priority Order

During this step, user needs are defined in detail. This is done in two steps. First, information is gathered about user needs and requirements. Second, this information is analyzed and priorities are assigned to the needs. Needs can range from broad Agency issues, such as security and privacy requirements, to specific information needs, such as certain exception reports or specific timing constraints.

Detailed information regarding user needs can be obtained by defining and analyzing problem areas, and by conducting and documenting interviews with system user and program management personnel. After the data regarding perceived user needs have been gathered and documented, users and management should be involved in analyzing and ranking these needs. Needs should be categorized as either "absolutely necessary", "necessary", or "nice to have". In each case a brief statement should be made about the potential cost and impact of not meeting the need.

The result of this step is a list of user needs in priority order, with detailed documentation supporting each need.

(4) Define and Rank Major Required Outputs From the Proposed System

During this step the set of user needs is translated into a set of outputs that are required to support these needs. A brief description should be provided of all required outputs from the system, such as printed reports, online displays, or updated data bases.

These outputs then should be reviewed to insure that they satisfy high and medium priority needs. If necessary, additional reports or more useful reports (such as exception reports) should be included. Note that the details of each field or data element on the reports need not be specified at this point, but a listing of all required outputs should be obtained from this step.

For each individual output requirement, indicate where the data supporting the output will come from, and how it will be entered into the system. Any special frequency or timing requirements should be included.

The result of this step is a complete list of potential system outputs that are needed to satisfy the set of user needs.

(5) Develop a Consolidated Statement of User Needs, Project Objectives, and Acceptance Criteria for Review With Management

During this step, a summary statement of user needs and project objectives is prepared from the documentation produced in the previous four steps of this task. The statement consolidates information on the program environment, user requirements, user priorities, departmental objectives, and any unique timing or cost constraints.

In addition, it is necessary to prepare a broad definition of what will constitute an acceptable product to the user. These acceptance criteria establish a basis for defining evaluation criteria and provide management with a basis for assessing the cost benefits of system solutions. Examples of acceptance criteria include seven considerations, as follows:

- Development and operating cost constraints
- Response time constraints
- Accuracy requirements
- Requirements for flexible reporting
- The ability to provide online retrieval of information
- The ability to maintain historical data
- The ability to process specified volumes of data within a given amount of time

In defining acceptance criteria, be as specific as possible, because the greater the level of detail that can be developed at this point, the greater the likelihood that the feasibility study will recommend a solution that will satisfy the user. The users should be involved actively in preparing this statement of acceptance criteria. If the users are unable to specify acceptance criteria in detail, the needs analysis should be reexamined to ensure its validity.

At this point, the consolidated statement of needs, project objectives and acceptance criteria should be presented to management for review. At the review meeting, additional needs or information may surface and should be included in the documentation.

The result of this step is final documentation on the needs analysis, project objectives and user acceptance criteria.

2. ANALYZE THE CURRENT OPERATIONAL ENVIRONMENT

In this task the current or proposed operational environment is defined in detail. The ability of current operations to support user needs are analyzed fully. This analysis serves as a useful base point for the development and evaluation of proposed alternative systems. In addition, a thorough analysis of current operations may indicate that improved operations or changed personnel responsibilities would yield substantial savings.

If the feasibility study is designed to address new legislative or regulatory requirements, then the purpose of this step will be to analyze existing systems within EPA to determine if any of them can be utilized effectively or converted to meet part or all of the new requirement. Thus, instead of analyzing and projecting existing workloads and transaction volumes, this step would prepare new estimates of expected workloads and usage profiles.

This task consists of five major steps, as follows:

- Define current information systems
- Define and analyze work loads and transaction volumes
- Define the costs of current systems
- Identify the deficiencies of current systems
- Identify potential savings and summarize the justification for studying alternatives

(1) Define Current Information Systems

This step applies to both manual methods and automated information systems, and consists of six activities, as follows:

- For those functions (relevant to the Feasibility Study) that the program office performs, define the information that is needed and the outputs that are created.

- Examine the information systems to determine the sources of necessary information and the destinations of outputs.

- Describe and categorize inputs and outputs. Ensure that the proper level of detail is maintained, by referring to categories and types of information as opposed to files and records.

- Describe the general flow of information, using diagrams where necessary. Hierarchical Input Process Output (HIPO) diagrams can be used effectively for this purpose.

- Describe any special management controls, timing considerations, statistical reports, or exceptional conditions to determine if any should be incorporated into proposed system designs. Six examples of management controls include:

    - Exception reports
    - Performance reports
    - Statistical reports
    - Data security controls
    - Double entry or double checking controls
    - Organizational controls, such as certain personnel being required to review or spot-check information

- Describe all interfaces with other systems. Interface characteristics should be documented by including four types of information, as follows:

- The data flowing across the interface
- The direction of the data
- The medium used, such as tapes or disk packs containing computer files, hard copy reports, or verbal communication
- The frequency and timing of the communication

The result of this step is a concise statement describing currently installed information systems that are relevant to the feasibility study.

(2) Define and Analyze Work Loads and Transaction Volumes

An analysis of current and potential workloads and transaction volumes is required for developing and evaluating alternative solutions. If detailed figures are not available, approximate estimates should be prepared for at least five system considerations, as follows:

- The characteristics and number of transactions should be defined, including their distribution during the day, month, quarter or year. It is important to define peak volumes of transactions and when they occur. Precise numbers should be obtained for transactions characterized by high volume, great complexity or extreme peaking.
- Any growth or decline in transaction volumes that may occur should also be defined, as projected increases in transaction volumes or file sizes can have a major

effect on the costs, benefits and features of the proposed system. The basis for all projections should be documented.

- If telecommunications links are a factor, the size of transactions should be defined. This is done by defining the pieces of information that characterize a transaction and translating this into a character or byte count.

- The number of records maintained in the major files also should be identified. In manual systems this information is often available from the personnel involved in the operation. In automated systems, file sizes and transaction volumes usually can be obtained from record counts.

- Response time requirements should be defined. Demand on personnel, machine time and other resources can be very high when transactions arrive in unusually large numbers at a particular time of the day, week, or month. If fast response is a requirement, peak periods can have a major impact on the design of the new system. Four indications of response or turnaround time requirements should be obtained, as follows:

    - The response time provided by current systems
    - The response time needed to meet departmental requirements
    - The "ideal" level of response time
    - The acceptable level of response time

  In defining the acceptable range of response time, it may prove useful to provide an indication of the cost or impact of not meeting certain requirements. Any potential trade-offs should be analyzed.

The result of this step is a documented analysis of current and expected workloads, transaction volumes, file sizes, peak volumes, timing considerations and response time constraints that proposed systems will have to support.

(3) Define the Costs of Current Systems

A complete analysis of current operational costs is an important input into the cost/benefit analysis that is performed in a later phase of the feasibility study. Costs should be broken down into two categories, as follows:

- Personnel costs may be developed by function, by job title or by function within job title. Costs may be expressed by the number of people or the number of hours. Monthly hours or percentages should be converted to annual hours, assuming a certain number of hours per person per month. The unit cost applicable to a specific job title or function depends on the grade of the people involved. The hourly rate, including overhead, should be obtained from the standard personnel grade chart.
- Non-personnel costs of current systems include six types of costs, as follows:
    - Computer costs which can be determined by obtaining computer bills for a given period.
    - Telecommunications costs, if any, can also be obtained by obtaining bills for previous months.
    - Peripheral machine costs are the costs for those machines, such as adding machines and typewriters, which are not included as computer costs. If the piece of equipment has been purchased, its purchase price, and maintenance costs should be obtained. If it is leased, the annual lease cost, terms of rental, service charges, and any penalty clauses should be defined.

- Materials cost, such as the cost of special forms, should be determined and included.
- Operating costs are any major recurring costs that occur, such as electricity and floor space costs. It may be necessary to document only those operating costs that will be eliminated in future systems.
- Maintenance costs usually are associated with automated systems which require corrections of errors, enhancements, tuning, or modifications because of changing needs.

The result of this step is completed documentation of current ADP expenditures for those computer systems which either may be replaced or be utilized partially to support the proposed application.

(4) Identify the Strengths and Deficiencies of Current Systems

A definition of the strengths and weaknesses of current systems is useful because it serves as input to the four activities peformed in a feasibility study, as follows:

- . Justifying the investigation of alternative systems
- . Developing proposed alternatives
- . Preparing evaluation criteria
- . Preparing user acceptance criteria

Examples of deficiencies of current systems include high costs, inadequate turnaround or response time, low degree of accuracy, inadequate control, poor management information and inadequate flexibility. Current systems are evaluated primarily as a result of interviews with users and operations personnel. Those functions which are receiving inadequate support should be identified. In addition, those needs that are being served adequately should be documented and retained in proposed alternatives.

The result of this step is a documented analysis of the advantages and disadvantages of using currently installed information systems to support new requirements.

(5) Identify Potential Savings and Summarize Justification for Studying Alternatives

An analysis of any potential savings or benefits should be presented at this point. Benefits can be quantifiable or intangible, as follows:

- Quantifiable savings can be firmly estimated and include reduced personnel, equipment or operating costs, as well as improved machine utilization or cash flow.

- Intangible benefits cannot be precisely quantified, but should be described in terms of improved service, improved information tracking, or in terms of furthering the objectives of the Agency.

A summary of the ability of currently installed ADP systems to support the new requirement should be presented, and a justification for studying alternatives should be made. Those features of current systems that should be retained to support the new requirements should be documented, as should the reasons why other features cannot be retained.

The result of this step should provide management with a clear picture of the ability of current systems to satisfy the new requirement, and the potential benefits that can be realized from studying alternative systems solutions.

3. DEVELOP EVALUATION CRITERIA

The purpose of this task is to prepare a set of evaluation criteria against which each alternative will be measured to determine its relative merit. Evaluation criteria should be meaningful to the decision process, and although specific criteria will vary, they should include three types, as follows:

- Functional criteria
- Technical criteria
- Economic criteria

There are four major steps in defining and weighting evaluation criteria, as follows:

- Develop functional requirements criteria
- Develop technical evaluation criteria
- Develop economic evaluation criteria
- Rank and weight criteria and secure user approval

(1) Develop Functional Requirements Criteria

In this step evaluation criteria are developed for use in determining how well a particular solution meets the defined functional requirements.

Functional requirements criteria should be developed after reviewing user needs, acceptance criteria, and the deficiencies of current information systems. Eight examples of functional requirements criteria include the following:

- The ability to meet current and future requirements. (Each requirement should be assessed individually.)
- The flexibility and expandability to respond to changes
- The ability to meet specific timing constraints
- The ease of use
- The lead time for development
- The ease of implementation
- The impact on other Agency programs and operations
- The ability to interface with other systems

The result of this step is a list of evaluation criteria that will be used to assess alternatives for their ability to meet the functional requirements.

(2) Develop Technical Evaluation Criteria

The objective of this step is to identify those technical issues that must be considered in evaluating the various alternatives. Nine examples of technical criteria include:

- Usage profile related criteria which consider the expected level of use of the various application functions and the corresponding response or turnaround time requirements for these functions.
- The match with current or planned hardware and software resources, in particular the COMNET, Univac or PDP 11-IAS computer configurations.

- Security considerations such as the ability to provide access restrictions for certain functions or portions of the data base.
- Data accuracy, which is dependent on the data representation methods used by the computer.
- Terminal support considerations which include four issues, as follows:
    - Polled or non-polled terminal needs
    - Dial-up access requirements
    - Desired transmission speed
    - Hard copy images of display screens
- File Management requirements, which include six considerations, as follows:
    - File types (sequential, direct, indexed sequential, linked lists)
    - Data base management system requirements
    - The ability to create and delete files under program control
    - The ability to provide file sharing with lockout on a record or block
    - File and data base manipulation utilities including copying, sorting, dumping and loading
    - Maximum record length and file size restrictions
- Performance considerations
- Development aids, such as report generation capabilities, and high level languages are desirable during development since they affect the ease, duration and cost of the development effort, as well as facilitate the maintenance and enhancement of systems once they are operational.

- Operating System features that are required during the development, operation and maintenance of the system. Ten examples of important operating system features include:

  - File editing capabilities
  - Printer Spooling
  - Device and user usage accounting
  - Debugging aids
  - File allocation and reorganization capabilities
  - The ability to provide background processing concurrent with online operation
  - Programming languages supported
  - Automatic backup facilities
  - Foreground initiated background processing
  - Support of industry standard tape labelling

The result of this step is a list of evaluation criteria that will be used to ensure that the alternatives fulfill the necessary technical requirements.

(3) Develop Economic Evaluation Criteria

One time and annual operating costs are often the most important criteria in selecting amongst alternatives. Eight examples of economic criteria that should be defined include:

- One time personnel costs for development
- One time computer charges for development
- One time hardware costs, including costs of computers, peripheral devices, and terminals
- Annual personnel and computer charges for operations
- Annual personnel and computer charges for maintenance
- The cost/savings relationship for each alternative
- The risk factors involved for each alternative

The result of this step is a definition of the economic criteria that will be used in evaluating alternatives.

(4) Rank and Weight Criteria and Secure User Approval

The purpose of this step is to assign weights and priorities to evaluation criteria, so that they can be used effectively in the analysis of alternatives.

Weights should be assigned on a scale of 0-10. The functional requirements criteria should be weighted by using the ranking of user needs and requirements as a guideline. The technical requirements criteria should be weighted by someone that is technically proficient, and has studied the functional requirements and translated them into a set of technical requirements. Weights should be assigned to the risk factors and various economic criteria by the program managers involved.

The list of weighted evaluation criteria should be reviewed and revised with management personnel until there is general agreement regarding the weights assigned.

The result of this step is a weighted list of evaluation criteria that will be used to analyze the alternative solutions to be developed in the next task.

4. IDENTIFY AND DESCRIBE ALTERNATIVE SOLUTIONS

In this task a number of alternative solutions are developed from which a recommended approach will be selected. Proposals should be developed by reviewing the outputs of prior tasks, particularly the needs analysis. Alternatives may range from simple manual systems to sophisticated automated systems. There are two steps in this task, as follows:

- List all reasonable alternatives and perform initial screening
- Describe in detail each alternative solution

(1) List All Reasonable Alternatives and Perform Initial Screening

In this step a comprehensive list of all alternative solutions is prepared, from which some will be selected for further detailed analysis. As many alternatives as possible should be included. Minor variations within a particular solution should not be considered as alternatives because a valid alternative must have some unique element in terms of capability, cost, effort, technical configuration, risk, control requirements or ease of use and convenience. Alternatives can be developed by proposing different degrees of functional support, varying degrees of automation, and different technological alternatives.

Four options which should be considered in listing alternatives include:

- Maintain the current system. In this case the impact of not doing or delaying the project should be evaluated. The advantages and disadvantages of this alternative form a useful base point for evaluating other solutions.
- Make minor manual changes. This is a viable option if the existing manual procedures can be changed to satisfy some of the objectives.
- Make computer system changes. The advantages and disadvantages of utilizing current computer systems should be considered.
- Develop a new computer system. Within this alternative there may exist a number of computer systems that satisfy different sets of functional requirements. In addition, new computer systems can be built around one of many technological alternatives, including the UNIVAC, COMNET, or PDP-11 minicomputer hardware configurations.

When developing technical alternatives, the UNIVAC or existing minicomputer configurations should be considered first because the equipment is owned by the Agency. The COMNET capability should be selected second because of the existing facilities management arrangement, while new minicomputer alternatives should be considered last because they involve the purchase of new equipment.

The initial list of alternatives then should be mapped against the evaluation criteria to assess their suitability in meeting user needs. Some alternatives can be rejected immediately due to substantially higher costs, a longer time frame for development, or a greater degree of development risk. From this list between three and seven alternatives are selected for further analysis.

The result of this step is a list of alternatives that warrant additional analysis.

(2) Describe in Detail Each Alternative Solution

In this step an overall description of each alternative is provided which explains in general terms how it applies to the problem at hand, such that someone without any prior knowledge of the system would be able to understand the key concepts. The description should include seven types of information, as follows:

- A general description of the major features of the system, including diagrams where appropriate.
- A description of the hardware environment including CPU's, terminals, printers, communications equipment and telecommunications lines.

- A description of the software environment, including operating system features, and data base and systems software that will be used.
- The major functions that are automated in this alternative
- Interface, backup, recovery and reorganization procedures, as well as any other operational considerations should be addressed where necessary.
- A summary of the major benefits of this approach, including both cost savings and intangible benefits.
- An analysis of the major functional advantages and disadvantages of this approach.

5. EVALUATE ALTERNATIVE SOLUTIONS

In this task the advantages and disadvantages of the alternatives are measured against the set of evaluation criteria, and are presented in a manner that facilitates easy comparison. The evaluation is performed by computing potential annual benefits, as well as annual operating expenses and one-time costs. Scores are assigned to the weighted set of evaluation criteria for ranking the alternatives.

There are five major steps that should be performed in evaluating alternatives, as follows:

- Estimate one-time costs for each alternative
- Estimate recurring costs for each alternative

- Estimate the lead time for development for each alternative
- Prepare a cost benefit and cash flow analysis for each alternative
- Assign values to each alternative against the evaluation criteria and rank alternatives

Appendices A, B, C and D contain specific guidelines and estimation rules to support these activities.

(1) Estimate One-Time Costs for Each Alternative

The purpose of this step is to estimate the cost of people and machines to bring each of the alternative proposals into operation. The degree of accuracy provided by this estimate depends on the amount of system design work that has been done up to this point. Because a detailed system design is rarely available at this point in the feasibility study, it is difficult to estimate precisely all factors that make up the total development cost figure. Six examples of factors that will still be unknown include:

- The size of programs
- The complexity of programs
- The analyst and programmers to be assigned to the project
- The degree of user involvement

- The degree of access to the development computer
- The amount of new code that has to be written

However, determining personnel and machine costs are an integral part of the feasibility study and can be estimated within a reasonable approximation by expanding upon the preliminary system design assumptions. Estimates that are required include three types of costs, as follows:

- Personnel costs incurred in the detailed design phase of the project during which a set of detailed specifications are prepared and programs are designed
- Personnel and machine costs incurred during the programming and testing of the proposed system
- Personnel and machine costs incurred during the conversion, installation and parallel operation of the system

Personnel costs should include both the cost of programmers and systems analysts, and the cost of consultants, data entry clerks and the time spent by users with the software development team. The programming effort should be divided into the smallest distinct phases possible using the guidelines and rules of thumb provided in Appendix A. Costs of computer time that are incurred during the programming and development of the system can be calculated using the guidelines in Appendix A.

The initial estimates can be double checked by requesting software vendors or consultants to prepare independent estimates for some or all the phases of the development effort. An additional check can be made by comparing the cost estimates for each proposal to the costs of recently completed projects with similar characteristics.

The result of this step is a set of estimates for one-time costs for each alternative proposal.

(2) Estimate Recurring Costs for Each Alternative

In this step the annual personnel and machine costs for the operation of each alternative are estimated for the expected life of the system. Appendix B of this report provides a number of guidelines and rules of thumb for estimating recurring machine and personnel costs.

Machine costs can be estimated for a given alternative in three ways, as follows:

- Obtaining the advice of consultants at COMNET or the UNIVAC facilities
- Basing machine cost estimates on past experience with operation of similar systems

- Applying the formulas in Appendix B, making assumptions about the characteristics of the system. These formulas are based on making realistic assumptions about the number and frequency of the different steps within each job, and calculating the computer resources required for each step.

Personnel costs include the costs of data entry clerks, system managers, and any additional staff that will be required to support new functions. In addition, personnel costs are incurred for maintenance programming and the addition of minor enhancements. Major enhancements need not be estimated as these should be cost justified on their own.

The result of this step is a set of estimates for the annual operating costs for each alternative system proposal.

(3) Estimate the Lead Time for Development for Each Alternative

Estimating the length of time before a given alternative can be made operational is a necessary and important input into the preparation of the cash flow analysis and the whole decision making process. The total number of person months for the development of each alternative usually is calculated when preparing development costs. By using critical path techniques and PERT charts, and by making assumptions about the number of people to be assigned to the project, the total elapsed time necessary to complete the task can be determined. The project should be decomposed into small tasks and the elapsed time necessary to complete each task should be identified. Appendix C of this report contains detailed information on the preparation of PERT charts, GANTT charts and related methods.

The result of this activity is an estimate of the elapsed time necessary for the development of each alternative system.

(4) Prepare a Cost Benefit and Cash Flow Analysis for Each Alternative

The costs and savings estimates developed in the prior steps are summarized in this step to provide management with a measure of the dollar value of each proposal. This is done by preparing a detailed cash flow analysis and calculating the discounted cumulative savings for each proposal.

A detailed explanation of how a cash flow analysis should be prepared is described in Appendix D of this report. Costs or expenses for each proposal should be presented as shown in Exhibit D-1 in Appendix D. Development costs and maintenance costs are shown in the years that they are incurred. Quantifiable savings including displaced costs and indeterminate benefits should be presented as shown in Exhibit D-2. The cash flow should be carried through to the last year of operation, which is the point where the system becomes obsolete and should be replaced. The final step in preparing the cash flow analysis involves calculating the discounted net present value of the cumulative savings for each proposal using a table of discount factors. At present, GSA suggests using a 10% discount factor.

The result of this step is a dollar figure representing the net present value of the discounted cash flow for each alternative system proposal.

(5) Assign Values Against Criteria and Rank Alternatives

In this activity values are assigned for each alternative for the various functional, technical, and economic criteria that were developed in Task 3. Exhibit 2-2, on the following page, shows a useful matrix for evaluating proposals. Scores are assigned within a range of 0-10. The 0 implies the proposal does not satisfy the requirement at all whereas a 10 implies the proposal completely satisifes the requirement. Scores should then be multiplied by the weights assigned to the criteria and summed to arrive at the total weighted score for

Exhibit 2-2

U.S. ENVIRONMENTAL PROTECTION AGENCY
Sample Matrix To Be Used in Evaluating Alternatives

		ALTERNATIVES			
EVALUATION CRITERIA	Wt.	Alt 1	Alt 2	Alt 3	Alt 4
FUNCTIONAL					
. Flexibility	5	8	4	6	3
. Ease of Use	7	3	9	2	8
. Interfacing	5	5	6	4	8
TECHNICAL					
. Data Security	9	10	3	7	4
. DBMS	8	8	6	4	7
. Online Access	7	3	5	10	3
ECONOMIC					
. Fixed Costs	5	8	7	6	5
. Recurring Costs	7	10	5	6	7
WEIGHTED TOTALS		371	293	301	298
RANK		1	4	2	3

each alternative. The final scores then indicate the rank of each alternative.

At this point, any other intangible or non-quantifiable considerations should be considered to make the final ranking of alternatives. Users as well as management personnel can be involved to prepare the final ranking.

The output of this step is a weighted scoring of alternatives that result in a final ranking.

6. DEVELOP RECOMMENDATIONS AND REVIEW WITH MANAGEMENT

This task consists of three major steps, as follows:

- Develop recommendations
- Consider staging of the project into phases
- Prepare a summary of analysis for review with management

(1) Develop Recommendations

In this step recommendations are made based on the preceding analysis of quantifiable and intangible costs and benefits. Since quantifiable benefits for savings are more easily measured and therefore more reliable, they usually have the greatest impact on recommendations. Benefits should be weighed against the development costs over the expected life of the proposed system. The cost savings summary provides the information necessary to perform the cost benefit analysis and develop recommendations. If no savings are provided, the recommendations should be based on the perceived value of the intangible benefits and a decision should be made regarding which alternative provides the greatest value for the least amount of money and best fits the objectives and constraints of the functional requirements.

The result of this step is a decision regarding the alternative best suited for further investigation.

(2) Consider Staging of the Project Into Phases

Before recommendations are made to management, it is important to determine whether the lead time for making the system operational can be reduced by developing the system in distinct phases. Phasing of the project provides initial capabilities early, thereby yielding some benefits immediately, while the less critical capabilities are brought up at a later point in time. Serious consideration should be given to phasing of the project, especially when the future environment is uncertain and projected benefits tend to be indeterminate or intangible.

(3) Prepare a Summary of Analysis for Review With Management

In this step the findings to date are reviewed in a presentation before management. A draft of the documentation produced to date should be distributed before the meeting, including:

- The needs analysis
- The analysis of the current environment

- The documentation describing the alternative system solutions
- The analysis of alternatives
- The cash flow analysis that has been prepared for each solution
- The summary chart comparing each alternative with the final ranking
- The recommendations and the reason for selecting the alternative

The presentation to management should summarize the analysis and findings, discuss each of the alternatives in detail, and present the reasoning behind the recommended approach. A period of discussion usually follows the presentation and additional analysis may be performed as a result of this discussion. A final recommendation then is prepared.

The result of this step is a final recommended approach that warrants further investigation. The remainder of the feasibility study consists of refining the cost estimates and system design of this recommendation to a further level of detail.

7. PERFORM INITIAL SYSTEM DESIGN

In this task a more detailed design of the recommended system is prepared, to facilitate the development of a more refined economic analysis and project plan. This task consists of five major steps, as follows:

- Prepare a detailed system description including hardware or network configuration
- Define the outputs of the system
- Define the input functions
- Define the processing flow of the system
- Define the major data bases and conversion requirements

(1) Prepare a Detailed System Description for the Selected Alternative.

In this step the selected alternative is described at a lower level of detail than in Task 4. This is done by means of system diagrams accompanied by a narrative description of the system.

The system diagrams show the major master and transaction files, the hardware configuration, communication lines and the major input and output functions. A sample system diagram is shown in Exhibit 2-3, following this page.

The accompanying narrative should describe five major features of the system, as follows:

- The hardware requirements and hardware configuration
- The major files and data bases in the system
- The output reports and output data bases
- Any special features of the operating system that are utilized, such as data base management or report generating capabilities
- The major conversion and testing requirements, and the degree of user involvement

The result of this step is a detailed description of the system solution that has been selected.

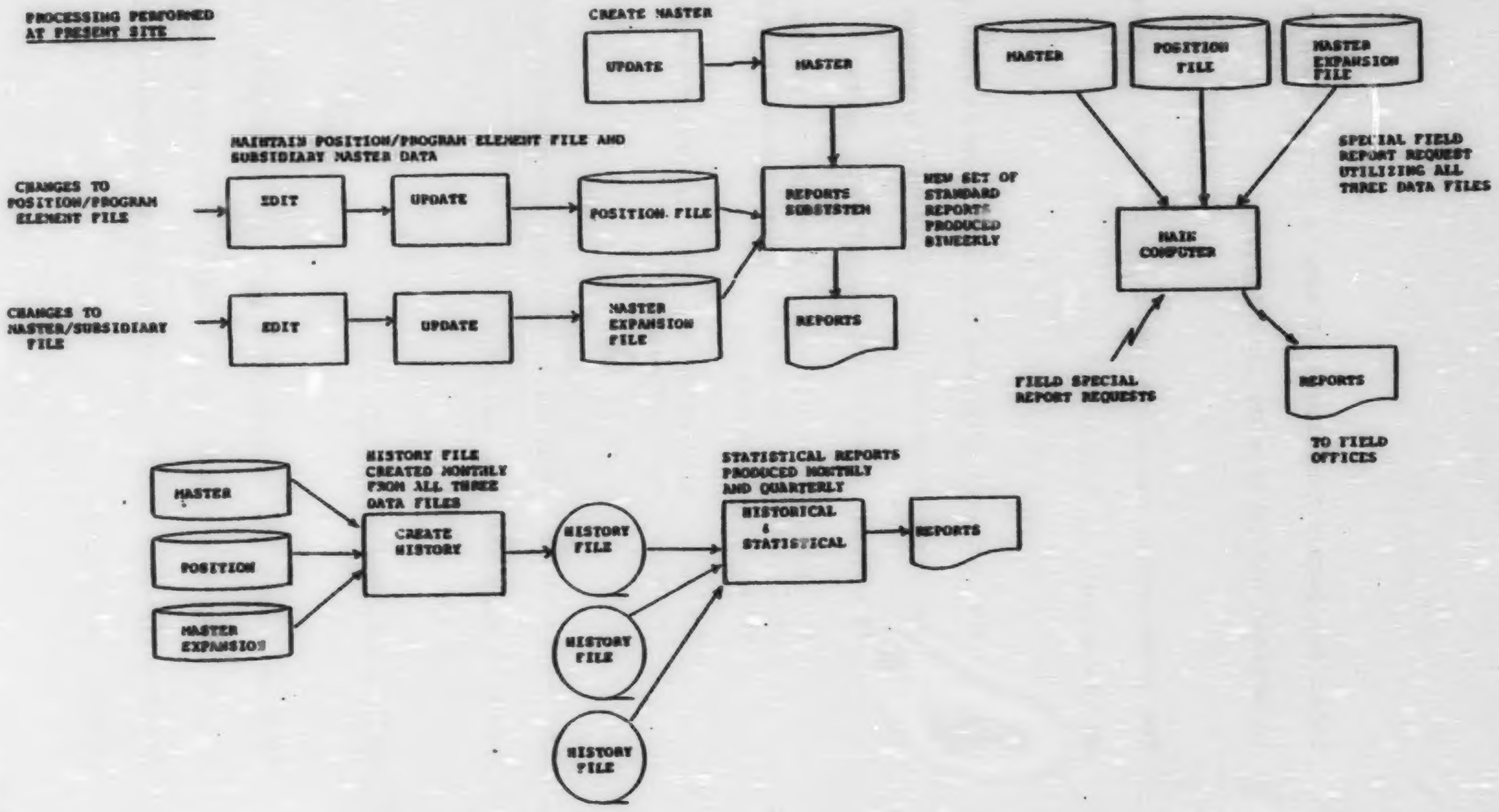
(2) Define the Outputs of the System

This step consists of preparing a brief description of all output reports and data bases that will be generated from the proposed system. Eight issues should be addressed for each output, as follows:

Exhibit 2-3

U.S. ENVIRONMENTAL PROTECTION AGENCY

Sample System Diagram


PROCESSING PERFORMED AT PRESENT SITE
CREATE MASTER
UPDATE
MASTER
MAINTAIN POSITION/PROGRAM ELEMENT FILE AND SUBSIDIARY MASTER DATA
CHANGES TO POSITION/PROGRAM ELEMENT FILE
EDIT
UPDATE
POSITION FILE
REPORTS SUBSYSTEM
NEW SET OF STANDARD REPORTS PRODUCED BIWEEKLY
CHANGES TO MASTER/SUBSIDIARY FILE
EDIT
UPDATE
MASTER EXPANSION FILE
REPORTS
MASTER
POSITION FILE
MASTER EXPANSION FILE
SPECIAL FIELD REPORT REQUEST UTILIZING ALL THREE DATA FILES
MAIN COMPUTER
FIELD SPECIAL REPORT REQUESTS
REPORTS
TO FIELD OFFICES
MASTER
POSITION
MASTER EXPANSION
HISTORY FILE CREATED MONTHLY FROM ALL THREE DATA FILES
CREATE HISTORY
HISTORY FILE
HISTORY FILE
HISTORY FILE
STATISTICAL REPORTS PRODUCED MONTHLY AND QUARTERLY
HISTORICAL & STATISTICAL
REPORTS

- A description of the output, the number of copies to be distributed, and the users receiving the reports
- The types of information on each report including a description of the major fields
- The primary source of the information on the report, (i.e. which data bases are accessed).
- Sorting requirements, and summarization and calculation rules
- Any special post-processing controls or exceptions associated with the output
- Any special forms needed (as opposed to using blank stock)
- Whether the report is requested on demand or produced automatically

After defining the major fields in each report, a check should be made to ensure that a corresponding input exists.

The result of this step is a description of the output that will be produced from the proposed system.

(3) Define the Input Functions

In this step the input functions for the proposed alternative are defined in detail. In particular, the following issues are addressed for each input.

- A statement of purpose for the input function

- A list of the major fields that are input into the system
- A description of how the data is input and by whom
- A description of the major edit checks performed
- A description of any pre-computer processing controls
- The data bases that are affected by each input function

The result of this step is a description of each input function in the proposed system.

(4) Define the Processing Flow of the System

This activity consists of describing the major processing steps of the proposed system. It consists of a system narrative which summarizes the major functions that would be performed by the system in terminology that can be understood by a layman. In addition, five issues should be addressed for each processing step in the system, as follows:

- The major calculations involved
- The major decision making points within the processing step
- The data bases that are affected or updated
- An overview flow diagram for each processing step
- The interfaces with other processes

The result of this step is a description of the major processing steps of the proposed system.

(5) Define the Major Data Bases and Conversion Requirements

In this step the major data storage requirements are defined, together with a discussion of the resulting conversion requirements.

Eight issues should be addressed in defining the major data bases, as follows:

- A statement of purpose of the file or data base
- A sample record layout showing the major data elements
- A description of the major data elements in each record
- Any special linkage or access method requirements
- The approximate length and size of the file. This information can be obtained from the transaction volume and data base size estimates generated in Task 2.
- Backup or file reconstruction considerations
- Authorization or restriction requirements
- Miscellaneous information, such as retention requirements and online data accessibility.

After defining the major data bases, it is important to describe the conversion requirements for each data base. The description should include five major areas, as follows:

- The source of all conversion data
- The mechanism for conversion, whether manual or computerized
- The amount of data that needs to be converted
- A projection of how long the conversion process will take
- Any special requirements for the converted data

The result of this step is a description of the major data bases in the proposed system as well as the associated conversion requirements.

8. PREPARE A DETAILED ECONOMIC ANALYSIS FOR THE PROPOSED ALTERNATIVE

In this task the cost estimates for the proposed alternative are refined to reflect the information gained from the more detailed system design. The steps in this task are similar to those performed in a prior phase except that there is more detail involved. There are four steps in this task, as follows:

- Estimate in detail all development and fixed costs
- Estimate in detail all operational costs
- Prepare a detailed list of savings for this alternative
- Prepare a final cost benefit and cash flow analysis

The detailed methodology to be followed for completing this task is described in Appendices A, B; and D.

9. DEFINE USER ACCEPTANCE CRITERIA AND PREPARE A PROJECT PLAN FOR THE PROPOSED ALTERNATIVES

In this task the set of user acceptance criteria are defined and a plan of action for the remainder of the project is prepared. This plan describes the remaining phases showing project milestones and checkpoints and elapsed time for each phase. There are three steps in this task, as follows:

- Define user acceptance and system measurement criteria
- Plan the detailed design phase
- Prepare a project plan for the remaining phases

(1) Define User Acceptance and System Measurement Criteria

Every feasibility study should include a definition of user acceptance criteria to establish what will constitute an acceptable system. The criteria also are useful in analyzing system specifications and assisting the user in defining roles and responsibilities associated with the new system.

A set of yardsticks should be established that will be used to determine how well a system has met the objectives and needs that have been defined. These yardsticks will be used after installation to determine the success of the system and to highlight the need for any subsequent modifications. Measurement criteria should address four areas, as follows:

- How well has the system met the perceived needs and objectives?
- How well has the system met the development and operating cost restraints?
- How well has the system met the savings objectives?
- Do the acceptance criteria include accuracy and timing constraints, and any other special considerations that are critical to the operation of the system?

(2) Plan the Detailed Design Phase

The detailed design phase specifies the system solution that has been chosen to solve the problem described in the feasibility study. The design specifications are the foundation for all programming and implementation. The design logic should satisfy all required functions and define all interfaces, system files, and logic connecting all program modules. The design should be of sufficient detail so that all logic problems are resolved and the complete program system is integrated. There are nine major tasks in the design phase, as follows:

- Plan the design phase
- Start up
- Develop design standards
- Develop change control procedures
- Produce design specification, including:
  - Review general design goals
  - Review feasibility study and other documents
  - Define the major files and their contents
  - Design interprogram flow
  - Determine the interrelationships of various system programs
  - Design system structure
  - Revise and complete design
- Produce the conversion specifications
- Produce the coding standards
- Produce an internal training plan
- Review

Appendix E of this report presents more information regarding each of these tasks in the detailed design phase.

Before a project plan can be prepared for the detailed design phase, it must be decomposed into a set of individual tasks that consist of 80 hours or less in duration and have a tangible output. It is important to include all tasks identified in Appendix E because incorrect estimates are primarily due to tasks having been omitted rather than tasks having been recognized and underestimated. Therefore, all aspects of the design phase should be considered. The next step is to provide a brief destription for each task that has been identified and the professional skills, technical support and clerical support required for each task.

For each task specified, the number of hours required to complete the task should be estimated. A precedence network then should be created as described in Appendix D. A GANTT chart showing individual assignments and schedules can be prepared also if the individuals are known. Budgets should be assigned assuming a set of billing rates as shown in Appendix E. The project schedule then should be prepared with key milestones indicated.

The result of this step is a detailed plan for the design phase of the project.

(3) Prepare a Project Plan for the Remaining Phases

There are three major steps following the detailed design phase in the project life cycle, as follows:

- Detailed program specifications
- Programming and testing
- Conversion and installation

A somewhat less detailed plan should be prepared for these phases following the methodology described in Appendix E. The key activities in these phases are shown in Appendix A for development estimates. Key elements that should be summarized include:

- Project milestones which indicate specific accomplishments. The project plan should contain a list of key milestones with specific target dates and deliverables for their completion
- Manpower and cost schedules which can be shown by use of a chart
- Precedent networks which can be shown by use of a PERT chart showing the critical path of the project

The detailed task should be estimated for these phases shown in Appendix A. The methodology to be used in preparing the project plan is shown in Appendix C.

The result of this task is a project plan for the remaining phases of the project.

III. GUIDELINES FOR EVALUATING FEASIBILITY STUDIES

In order to ensure that the feasibility study is effective, accurate and properly focused, periodic reviews be held with management and user personnel throughout the feasibility study process. An integral part of the methodology in this report includes four major review points, as follows:

- There is an initial review meeting after the project team has analyzed user needs and current systems, and has developed and weighted the evaluation criteria.
- The second review meeting occurs after the alternative solutions have been identified and described.
- The third review meeting occurs when the evaluation of alternatives is complete and a recommendation has been made.
- The final meeting reviews the refined system design and the detailed economic analysis.

After the four review meetings, the draft of the feasibility study report should be delivered to user and management personnel. This should occur at least two weeks before the final publication deadline.

The remainder of this chapter suggests guidelines and checklists to be used both in the review meetings as well as in reviewing and evaluating the draft of the feasibility study report. It addresses four major areas of review corresponding to the four review points of the feasibility study.

1. REVIEW THE NEEDS ANALYSIS, THE ANALYSIS OF CURRENT SYSTEMS AND THE EVALUATION CRITERIA

The first step in a feasibility study consists of a definition of the scope of the project and an analysis of user requirements. Current systems should have been investigated to determine whether or not they can support the requirements. After having obtained a good understanding of the needs of the program office and the deficiencies of current operations, a set of evaluation criteria should have been prepared that will be used to determine the suitability of alternative solutions.

(1) Examine the Needs Analysis

The purpose of evaluating the needs analysis is to determine whether the project team was working within the proper constraints of scope, and possessed a good grasp of the problem. The examiner should investigate the eleven issues in relation to the needs analysis, as follows:

- Has the scope of the project been clearly defined? Were those requirements that were outside the scope also clearly defined?
- Are the overall objectives and scope reasonable or should they be reduced? Is the project team trying to address too many needs at once?

- Is the project team focusing on meeting only the program offices' unique needs, or are they keeping in mind the interests of the Agency as a whole?

- Does the needs analysis indicate a good grasp of the functional requirements of the organizational structure, the experience and quality of the staff, and of existing ADP utilization and procedures?

- Does the needs analysis point to a clear statement of why a new system should come into existance?

- Have outside factors been considered such as new legislation and new requirements, that may change the scope in the future? Can other program offices impact the needs analysis and the project objectives? If so, have they been consulted? Will the needs expand or be modified because of such outside influences?

- Is there sufficient supporting documentation for all needs that have been described?

- Have all the needs been ranked in priority order? Is there a clear difference between critical, not-so-critical, and nice-to-have needs?

- Are there any factors which make implementation timing critical?

- Have needs been translated into specific project objectives and user acceptance criteria?

- Have the users been able to specify in detail what their criteria are for the acceptance of the system? Have they been specific enough?

In addition, it is very important that the needs analysis be thorough, complete, and well thought through, because the statement of user requirements and objectives become the driving force for all subsequent analytical work that will be performed both in the feasibility study and in future phases of the project.

(2) Examine the Analysis of Current Systems

The analysis of current systems should provide a concise description of the current operational environment such that the advantages and disadvantages of current information systems in supporting new requirements can be grasped readily. The analysis should be examined for thoroughness and completeness in addressing five questions, as follows:

- Has the current system information flow been clearly documented with diagrams where necessary?
- Have sufficient data been gathered for determining the costs of current systems?
- Have current or projected workloads and transaction volumes been defined?
- Have the strengths and weaknesses of current systems been identified in relation to the needs analysis?
- Have any areas for improvement in current systems been identified? How much original thinking has gone into the analysis?

(3) Study the Evaluation Criteria

It is important that an objective and accurate set of evaluation criteria be established prior to the investigation of various alternative systems solutions. It is important that they be objective and clearly reflect the users' functional requirements and acceptance criteria. Nine issues should be considered while reviewing the set of evaluation criteria, as follows:

- Have the evaluation criteria been clearly documented with sufficient justification for each?
- Have priorities been assigned to the evaluation criteria and translated into a set of weights?
- Are the users in agreement over the weights assigned to the evaluation criteria?
- Is there significant difference between the user acceptance criteria and the evaluation criteria?
- Are there any criteria that should have been included that have been omitted?
- Do the economic criteria establish gross ranges for estimates of costs?
- Are the technical criteria valid or are they simply statements of nice-to-have technical requirements?
- What are the criteria for evaluating risk? Have issues defining risk, such as late vs. early payback, new vs. old technology, flexibility, adaptability, and degree of user sophistication been considered?
- Do the relative weights assigned to the criteria appear reasonable?

2. REVIEW PROPOSED ALTERNATIVE SYSTEMS SOLUTIONS

Questions that should be answered when evaluating the alternative proposals include:

- Has the study considered cancelling further work on the project? Is there really a need for automation?

- Has the impact of either delaying or not doing the project been explained clearly?

- Are the proposals technically as well as operationally feasible?

- Has the possibility of modifying existing systems to meet the objectives been examined thoroughly?

- Have the alternatives been clearly described, listing the advantages and disadvantages of each and the potential impact on other Agency operations?

- Has a new manual approach been considered if the volume is low enough and there exists a high proportion of non-standard, judgmental, or exception activity?

- If a new computer system is being proposed, are the requirements stable enough to justify the expenditure of money for developing a new system? Are the volumes of transactions high enough? Are they characterized by being highly repetitive and having standard rules for decision making?

- If a new computer system is being proposed, have all hardware and technological alternatives been considered?

- Are the proposals biased towards one particular alternative, e.g. is the feasibility study simply making a case for a minicomputer?

- Have the UNIVAC and COMNET facilities been included as viable alternatives? If not, why not?

- Are the technological alternatives chosen consistent with the technological requirements? For example, if online access has been stated as a requirement, it should be ascertained whether the user really does need online capabilities. Is there a need for online correction of data entry or immediate updates to reports? Is there a clearly stated quantifiable benefit because of interactive processing? What would be lost by performing functions in batch mode?

- If a minicomputer alternative is being proposed, what is the justification? Are there a great number of functions that need to be run on demand, or is there perhaps a requirement for a local data base within a distributed processing network?
- Are there additional alternatives that have not been considered that should have been?

3. EXAMINE THE EVALUATION OF ALTERNATIVES AND THE RECOMMENDATION

There are three major areas that should be addressed in evaluating the recommended approach, as follows:

- The cost benefit analysis
- The evaluation of alternatives against the evaluation criteria
- The factors that make up the final recommendation

(1) Evaluate the Cost Benefit Analysis

The cost benefit analysis should be examined to ensure that a complete and thorough analysis has been made. Factors that should be considered include the following:

- What assumptions in estimating were made?
- Were all factors that make up costs considered?
- How were development costs determined?

- How were operational costs developed? Were technical personnel involved in the estimating process?
- Have any costs been left out, such as the costs of user involvement?
- Have the benefits for each alternative been stated explicitly?
- Has an attempt been made to assign dollar values to intangible benefits?
- Has a cash flow analysis been completed? Is it correct? What assumptions were made, if any?
- If the resultant cost is negative, what are the implications? This may be acceptable because certain mandated projects may not have to be cost justified.
- Was the estimating methodology consistent across alternatives?
- Are the costs within the maximum acceptable range?
- Have costs been broken down by project phase?
- Have the costs of conversion and maintenance personnel been included?
- How was the expected operating life calculated? Is it correct and reasonable? Does this life change the justification for developing a system at all?
- Is the break even point acceptable?
- Have the development and operating cost estimates been cross-checked?

(2) Review the Scoring Against the Evaluation Criteria

The purpose of this step is to check the scoring of alternatives against the weighted set of evaluation criteria.

A useful way of doing this is to duplicate the evaluation process independently. This can be done by reading the documentation on the proposed alternatives, and, starting with a blank matrix as shown in Exhibit 2-2 of this report, to fill in the appropriate values and to arrive at a set of weighted values and ranks for each alternative. This then should be compared against the figures produced by the project team. Discrepancies may indicate that the documentation for the alternatives was not complete.

(3) Evaluate the Final Recommendation

In this step the recommendation is evaluated for reasonableness based on the work done in the prior phases. Seven questions that should be answered include:

- Does the information in the report support the recommended alternative?
- Has sufficient information been provided to enable management to evaluate the recommendation?
- Has the recommendation been justified primarily on intangible and indeterminate benefits? Is this acceptable?
- Was the methodology in arriving at the recommendation consistent and correct?
- Is the recommendation acceptable to all parties concerned? If not, why not?

- Is the recommendation consistent with the objectives of the Agency as a whole?
- Is the recommendation technically, economically and operationally sound?

4. REVIEW THE ECONOMIC ANALYSIS, DETAILED SPECIFICATIONS, PROJECT PLAN AND ACCEPTANCE CRITERIA

This review ensures that the detailed work performed after the initial recommendation is thorough and complete. Four areas should be reviewed at this point, as follows:

- The detailed economic analysis
- The detailed system specifications
- The user acceptance criteria
- The project plan schedule and budget

(1) Review The Detailed Economic Analysis

The checklist for reviewing the detailed economic analysis is similar to that provided for reviewing the preliminary economic analysis, except that the reviewer should ensure that the analysis is at the proper level of detail. Specifically, the reviewer should check for nine major points, as follows:

- What assumptions were made?
- Were tasks decomposed to a low enough level of detail?
- Were programs categorized by complexity?
- Have expenses and computer costs been included in the estimates?
- How were design costs estimated?
- Is there a separate estimate for conversion?
- Were all the factors listed in Appendix B considered in estimating operating costs?
- Has a new cash flow analysis been prepared?
- Does the cash flow analysis correspond to the project plan?

(2) Review the Detailed Specifications

Five major areas should be addressed in reviewing the detailed systems specifications, as follows:

- The general system description
- The specification of the outputs
- The specification of the inputs
- The specification of the processing flows
- The specification of the data bases and conversion requirements

The general system design should be reviewed to ensure that the system has overcome the problems identified in current systems and meets the new requirements identified in the feasibility study. The design should be as hardware independent as possible, and should provide a maximum of flexibility and portability. A system diagram should show the major input, output and processing functions. Future enhancements or features should be indicated by dotted lines.

The major outputs of the system should be reviewed for completeness. All major outputs should be documented together with any necessary information, such as timing requirements, audit trails and access restrictions.

The description of the processing flow should include a processing diagram for every major step in the system, accompanied by a narrative description of the major controls, processing steps, and interfaces.

The input function descriptions should be reviewed for clarity and completeness. There are seven questions that should be answered, as follows:

- Have the sources of data been identified?
- Is it clear how the input functions affect the basic transaction and master files?
- Have the transaction volumes and growth projections been outlined for the major input functions?
- Who will be responsible for performing data entry?
- Have the major edit checks been defined?
- What input method is being used? Is it batch or online? Are cards or tape used?
- What are the precomputer processing control mechanisms for the input functions?

In evaluating the data bases and conversion requirements, the following questions should be answered:

- Have the major files been defined with their record layouts and primary field descriptions?
- Have data base sizes and retention requirements been defined?
- Has the source of all conversion data been defined?
- Has the mechanism for conversion been described?

(3) Review the User Acceptance Criteria

An important aspect of evaluating a feasibility study is to ensure that adequate measures and acceptance criteria have been established to ensure that the resulting system will meet the needs and objectives defined in the feasibility study. The program office should state, in writing, the procedures and criteria that will be used to determine the acceptability of the system. In particular, the reviewer should ensure that four major conditions have been met, as follows:

- The user acceptance criteria clearly state the set of program objectives that will be met, and also identify those needs that will not be satisfied or have been deferred.
- There is a clear statement of the cost savings as well as the intangible benefits that will result from the system.
- The maximum acceptable development and operating costs have been explicitly defined.
- The user has defined in writing the functional acceptance measures, including:
    - Timing requirements
    - Accuracy requirements
    - Types of processing that should be provided
    - Volumes of data that must be handled
    - Report generation requirements
    - Response time and turnaround time requirements

(4) Review the Project Plan

The overall project plan should be reviewed to ensure its completeness and reasonableness. This review should address nine issues, as follows:

- Has a detailed work plan been prepared for the detailed specifications phase?
- Does the detailed plan cover all tasks appropriate for this particular project?
- Do the time estimates appear adequate? What assumptions were made in converting person time to elapsed time? Were allowances made for time off, non-project activities and administrative overhead?
- Did the estimates receive an independent cross check?
- What methodology was used in making estimates? Was a PERT chart prepared showing the critical path prior to preparing a GANTT chart?
- Was the schedule adjusted to reflect past experience on projects of this nature with this particular program office?
- Does the plan include a formal control mechanism which will ensure accurate status reporting and the ability to respond to problems in a timely fashion? Has an appropriate number of checkpoints or milestones been established to ensure proper control?
- Have deliverables been established for each project checkpoint?
- Finally, does the overall project plan still appear reasonable?

APPENDIX A

GUIDELINES FOR ESTIMATING SYSTEM DEVELOPMENT COSTS

This appendix provides a methodology and rules of thumb that can be used in estimating the costs of the design and implementation of computer systems. These guidelines can be applied at a level of detail corresponding to the amount of system design that has been prepared at the time. If the initial design has not been prepared then the estimator must rely on assumptions about the general characteristics of the system before applying the methodology.

This appendix is divided into two sections, as follows:

- A general approach for estimating costs
- Specific guidelines and rules of thumb that can be applied in estimating the remaining one-time costs of the proposed system

1. THE GENERAL APPROACH TO ESTIMATING SYSTEM DEVELOPMENT COSTS INVOLVES DECOMPOSING THE PROJECT INTO DISCRETE TASKS AND ESTIMATING EACH TASK INDIVIDUALLY

This approach is applied when the system design is detailed enough such that the remaining phases can be broken down into distinct tasks. The estimates are prepared in discrete steps, the output of each step logically provides the input to the following step. There are five steps in developing estimates in this way, as follows:

- Identify the system scope and major assumptions
- Identify work products and major activities
- Identify individual tasks
- Identify resource requirements and estimate the size of tasks
- Complete the cost estimates

(1) Identify System Scope and Assumptions

Development estimates are influenced both by the system scope and by the assumptions that characterize the project. The scope will vary from system to system. Some systems may specify separate releases of individual subsystems, while others may require extensive system testing before or after installation. It is important that the scope and constraints of the project be completely understood before preparing the project estimates.

Factors such as anticipated system use, system life expectancy, estimated growth, cost justification, future enhancements and phased releases, have an impact on the depth and extent of effort that will be expended in the development phases. The

Program Office's informal expectations and attitudes toward the project influence the number and scope of the work products to be produced. Normally, these work products would include at least five outputs, as follows:

- Design specifications
- Test plans
- System and user documentation
- Design reviews
- User training

These expectations often are not written down, but rather are understood as a result of prior experience or informal discussions with the Program Office.

Project estimates are also influenced by the number of assumptions that have been made which can cause development estimates to change significantly. Estimates should be based on a reasonable and accurate set of assumptions to prevent major changes to the development plan. Project assumptions normally fall into ten categories, as follows:

- Functional specifications
- Hardware configuration

- Hardware delivery
- Software packages
- Software deliveries
- Development environment
- Responsibilities of other parties
- Project staffing
- Administrative overhead
- Contingency factors

Assumptions should be identified and agreed upon before attempting to estimate the costs and timeframe for the remainder of the project.

(2) Identify Work Products and Major Activities

In this step the work products and major activities for each phase should be defined. Appendix E contains a checklist of the tasks and activities that should be included in each of three remaining phases of the project life cycle. This task list should be expanded upon as necessary. In the next steps this task list will be defined at a lower level of detail for estimating purposes.

(3) Identify Individual Tasks

In this step the major activities that make up the work products are decomposed into individual tasks each of which have an identifiable output and are of less than eighty hours in duration. Since the structure and activities of a project may not be identical to any other project, it may be appropriate to select, add, delete, combine and rearrange the items on the checklist in Appendix E to meet the needs of a given project. However, all aspects of development should be considered, and a list of tasks in outline form should be prepared as they relate to the work products and activities.

A task code should be assigned to each task. This code serves as a convenient cross-reference used in other planning and control documents, including precedence networks and GANTT charts. A task code is a simple numbering scheme which denotes a hierarchical structure of the plan and leaves room for additions or changes as preferred. For example, 100 may depict the major activity while 110, 120 and 130 might be codes assigned to tasks that are included in the activity. A brief description for each task that clearly describes the job to be done should be included.

(4) Identify Resources and Estimate the Size of Tasks

For each task specified, four requirements should be identified, as follows:

- Professional skills
- Technical support
- Administrative support
- Computer resources required

Then for each task specified, the hours required to complete that task should be estimated. Tasks should require less than eighty hours of work and should be estimated in the same sequence as they will be performed. Estimates should be conservative because there are many factors that may increase the duration of a task including complex interfaces, a new development environment, changing requirements, or hardware and operating system constraints.

(5) Complete the Cost Estimates

After the number of hours and level of professional skills have been determined for each task in the remaining phases of the project, a budget should be prepared. This is done in four steps as follows:

- Calculate the total person/week requirements by summing the requirements for each task. After the total number of person/weeks for the project has been determined a factor should be included for administration of the project. This can be calculated by assuming that one day of administrative management is required for every person per week in the project after the first person. For example, if there are three people working full-time on the project, at least two person days per week will be required for management.
- Compute the cost of the project by using a billing rate of $1,000 per week. This billing rate can be adjusted to reflect the prevailing rate for contractor data processing personnel.
- The resulting estimate should be increased by 12% for contingency purposes.
  - Secretarial costs
  - Telephone costs
  - Reproduction costs
  - Report production
  - Travel and subsistence
  - Computer services
  - Communication lines and modems
  - Terminals

2. RULES OF THUMB FOR ESTIMATING CAN BE USED WHEN IT IS NOT POSSIBLE TO IDENTIFY INDIVIDUAL TASKS IN A PROJECT AT THE DETAIL LEVEL

A number of estimating techniques are used in the data processing industry today and a variety of rules of thumb have been developed. Where possible as much of the project should be estimated using the step-by-step procedure before applying these rules of thumb.

The guidelines in this section have been developed from three sources, as follows:

- Government studies on software development productivity.
- IBM statistics on software development costs
- Vendor experience in developing a large variety of software in a number of different development environments

The guidelines in this section can be applied with varying degrees of accuracy, depending on the amount of knowledge that the estimator has about the overall system, and the number and complexity of the computer programs to be designed and developed. The guidelines require that the estimator have at least some knowledge of the types (input, output or processing) and complexities of the individual programs, and that "guestimates" can be made about the major variables that influence the estimates. It must be noted that any method of estimating, whether based on intuition or on formal techniques is no better than the knowledge, experience and judgement of the estimator. Systems that have extreme requirements should be estimated using the step-by-step method outlined above.

An example is used to describe the rules of thumb. The example used is a small on-line system consisting of ten data-entry functions, eleven reports and two batch programs of varying complexity. A feasibility study has been completed which included an overall system design and listed the types of functions required.

The methodology used in applying the rules of thumb consist of seven steps for estimating costs, as follows:

- Estimate program complexity by applying certain rules of thumb
- Determine the total programming effort including five activities, as follows:
    - Designing program logic
    - Coding programs and developing test data
    - Testing and debugging programs
    - Preparing program documentation
    - System test and installation
- Adjust the estimates to reflect variables that influence development time
- Estimate effort required for the detailed specifications phase by use of a simple formula
- Estimate total personnel costs by multiplying the effort by billing rates
- Estimate machine costs required
- Have software vendors check estimates

(1) Estimate Program Complexity

The first step in estimating program development time consists of determining program complexity. There are four categories of program complexity, as follows:

- Simple programs consists of between 25 and 75 lines of new (application specific, non-library) code per program. For example, simple reports may consist of file dumps with perhaps one filter or one sort, while simple data entry programs consist of two-step data entry programs with a minimum of edit-checking and validation.
- Medium programs consist of about 75 to 150 lines of new code and involve indexed files coupled with sorts, filters and more complex validation.
- Complex programs consist of 150 to 300 lines of new code and involve multiple files, with sorts, filters and extensive validation, or multiple types of input per data entry program.
- There should be very few or no very complex programs in a system if modern data processing and structured programming techniques are used. Very complex programs consist of more than 300 lines of new code.

(2) Determine Programming Effort

Individual functions, (or steps within a batch program) should be analyzed to determine their complexity. A table should be prepared, as shown in Exhibit A-1 following this page, using the following rules of thumb:

Type of Program or Step	Average # of Lines of New Code	Time Required
Simple	50	1 week
Medium	100	2 weeks
Complex	200	3 weeks
Very Complex	400	6 weeks

The result from Exhibit A-1 shows a total programming effort of 53 person weeks. A person week estimate for administration then needs to be added. Fifty-nine person weeks of effort with a project team of 3 will require an elapsed time of twenty weeks or 20 x 2 x 1/5 or 8 weeks of administrative time, resulting in a total of 59 + 8 = 67 person weeks.

An alternate method, using lines of code, should be used to check this estimate. The total effort, E, in person weeks can be calculated using the formula:

$$22L^{0.91}$$

Exhibit A-1

U.S. ENVIRONMENTAL PROTECTION AGENCY
Estimates for Effort Required for Sample System

Complexity Rating	Reports	Number of Programs Data Entry	Processing	Systems	Total	Number Of Lines	Person Weeks
Simple	5	3			8	400	8
Medium	5	3	1	3	12	1200	24
Complex	1	2			3	600	9
Very Complex		2	1		3	1200	12
					26	3400	53

Where L is the # of lines of code in thousands.

In our example $E = 22 \times 3.4^{0.91} = 67$ weeks.

A mid-point between the two figures should be used if the numbers do not match exactly.

(3) Multiply Effort by the Variable Factor

A number of variables can influence development estimates substantially and should be factored into the estimates. Ten major variables are shown in Exhibit A-2 following this page. Weights should be assigned using 1.0 as the average. Weights will usually range from 0.7 to 1.3. A weight of 2 to a factor means that the development estimate should be doubled. The total effort that has been computed should then be multiplied by the product of all the factor weightings.

Exhibit A-2 shows this calculation for the sample system. Note that a weight of 0.8 has been assigned to factor #10 because the system is being built on a time shared minicomputer, which usually speeds up development time by providing faster turnaround time for test runs.

Exhibit A-2
U.S. ENVIRONMENTAL PROTECTION AGENCY
Weights To Be Assigned To Development Estimates

	Variable Description	Positive Medium Negative	Factor Weights
(1)	Customer Interface Complexity	M	1.0
(2)	User Participation in Definition of Requirements	P	0.9
(3)	Customer Experience With Application Area	M	1.0
(4)	Percentage of Programmers Who Participated in Specifications	N	1.2
(5)	Previous Experience With Operational Computer	P	0.9
(6)	Previous Experience.With Programming Languages	M	1.0
(7)	Previous Experience With Application	N	1.1
(8)	Overall Complexity of Code	M	1.0
(9)	Amount of Documentation to Be Delivered	M	1.0
(10)	Development Environment - Batch (3 runs/day) 1.2-1.4 - On-line Interactive 0.9-1.2 - Dedicated 0.7-1.0	P	0.8
Overall Weighting Factor (Multiply Weights)			0.85

In the example, the total programming effort is 67 x 0.85 = 57 person weeks.

(4) Estimate Effort for Design Phase

After having calculated the effort required for programming, a simple rule of thumb can be applied to estimate the effort required for the detailed design. The rule of thumb is that one sixth the effort (before multiplying the factor weightings) is required to prepare a set of detailed specifications as is needed to program them. Thus, the detailed design would require 67 x 1/6 = 11 person weeks of effort. This can be factored upwards or downwards as necessary.

Hence, for the example, the total development effort will require 57 + 11 = 68 person weeks.

(5) Estimate Personnel Costs

The cost estimates can be derived by multiplying the person week estimates by the average available billing rate per week for contractor software development personnel. At present, EPA can use an average billing rate of $1,000 per week. Thus the personnel cost for the example system would be $68,000.

(6) Estimate Machine Costs

There are several methods of calculating machine costs required during development. To prepare a very detailed figure the estimator must calculate four costs, as follows:

- The costs of on-line editing
- The costs for compiling programs
- The costs for running and testing programs
- The costs of integrated testing

However, during a feasibility study it is usually more appropriate to use two rules of thumb, as follows:

- Use $5 for every hour of programming time that has been budgeted. In our example, from Exhibit A-1, there were 53 weeks of programming time estimated. After multiplying by the 0.85 weighting factor we have

  $$53 \times 40 \times 0.85 \times \$5 = \$9{,}010$$

- A formula can be used, based on the total of programming effort required for the project, before weighting. The formula is

  $$1.1E^{0.81}$$

Where E is the effort in person months, (4.2 weeks to the month). Thus, in our example, we have

$$1.1 \times (53/4.2)^{0.81} = \$8,580$$

Thus, for our example we should use a mid-point of $9,010 and $8,580 or $9,000 as the machine costs for program development.

To calculate machine costs for conversion we need to determine the total number of hours of on-line connect time that is required. Connect time charges range from $25 to $65 an hour, with $35 an hour being a useful rule of thumb for on-line data entry for conversion. Charges for use of WYLBUR may increase this average cost by about $17 per connect hour.

(7) Have Software Vendors Check Estimates

This Appendix can only provide rough guidelines and rules of thumb that can be used for estimating. Independent estimates should be prepared by software contractors, who will be bidding on the work, to ensure the accuracy of the estimates.

APPENDIX B

GUIDELINES FOR ESTIMATING OPERATING COSTS

During a feasibility study it is often difficult to estimate accurately annual recurring operating costs because of the lack of knowledge about the detailed computer system design of each alternative under consideration. Therefore, the feasibility study team should consider three options, as follows:

- Obtain the advice of software specialists either at COMNET, at NCC, or from the hardware and software vendors
- Calculate computer costs by comparison with the operating costs of similar systems
- Make assumptions about the characteristics of the system and use the methodology described in this appendix

The first two techniques can be appropriate when preparing the initial estimates of operating costs for each of the alternatives. The third technique, which involves applying detailed step-by-step procedures, is appropriate once the recommended alternative has been selected and a more detailed design has been prepared.

There are eight major steps in estimating operating costs for a given systems, as follows:

- Divide the processing flow into discrete job steps
- Determine the values of the parameters necessary for estimating
- Calculate the I/O requirements for each step
- Calculate the CPU requirements for each step
- Calculate other hardware resources that are required
- Compute annual computer operating costs
- Calculate annual personnel costs
- Calculate annual maintenance costs

1. DIVIDE THE PROCESSING FLOW INTO DISCRETE JOB STEPS

All the functions that are performed by the system should be broken down into discrete "steps" of processing. The frequency with which each step is performed is determined to provide a basis for the total annual hardware resources required for operating the system. Exhibit B-1, on the following page, is an example of the table that should be prepared to identify the characteristics of each step in the system. Each processing step is identified together with an estimate of the annual frequency of the step, and a description of the processing flow for each step. The volume estimates are obtained from the needs analysis, and the processing flow description is obtained from the system design.

Exhibit B-1

U.S. ENVIRONMENTAL PROTECTION AGENCY
Sample Step Identification Table

Step #	Step	Volume	Annual Frequency	Processing Flow
1.	Process Transaction (Batch)	40/day	1400	Read Transaction File, Update Master File, Add 1 record apiece to 2 detail files
2.	Master File Listing	1/day	365	Pass Master File sequentially once
3.	Transaction Exception Report	1/week	52	Pass all detail files sequentially
4.	Backup Transaction File	1/day	365	Pass all detail files once
5.	Enter Transaction	40/day	1400	Read Input, Add to Transaction File, Read Validation File
6.	Master List by State	1/week	52	Sort Master File, then pass sorted file once

2. DETERMINING THE VALUES OF THE NECESSARY ESTIMATING PARAMETERS

An accurate estimate of total annual I/O operations and total annual CPU seconds utilized provides a basis for calculating operating costs under most computer charging algorithms. However, before these estimates can be made, information must be gathered for parameters reflecting the specific application, system design, data-base, operating system software, and hardware assumptions. Exhibit B-2, on the following page, is a table showing the parameters that are needed to prepare the estimates, including how they can be obtained and sample values for illustration purposes. EXCPs are the number of physical read and write operations, i.e., the number of blocks that are read or written. Work files, input files and output files should be considered also, as should the movement of modules within overlay areas. Paging rates should not be included since these are part of operating system overhead and will not be charged directly to the application software.

3. CALCULATE I/O REQUIREMENTS FOR EACH STEP

In this activity the annual I/O operations for each step are calculated from the system parameters and each step's processing description. The following two examples show how this calculation

Exhibit B-2
U.S. ENVIRONMENTAL PROTECTION AGENCY
Estimation Parameters

PARAMETER	HOW TO CALCULATE	VALUE USED IN EXAMPLE
Number of Master Files	From System Design	1
Number of Detail (Transaction) Files	From System Design	2
Number of Records in Master Files	From Needs Analysis Estimates	200
Number of Records in Detail Files	From estimates of Transaction Volumes	Detail(1) = 1000 Detail(2) = 500
Size of each record	From estimate of characters in each record	Master = 500 Detail = 100 & 200
Size of block	From characteristics of hardware configuration	2048
"Blocking factor" for each file, i.e., number of records that can be read in one I/O operation (EXCP)	$\frac{\text{Size of block}}{\text{Size of each record}}$	Master = 4 Detail = 100 & 200
I/O operations required to read an entire file sequentially	$\frac{\text{Number of records}}{\text{Blocking factor}}$	Master = 125 Detail = 5 & 20
EXCPs required to retrieve a record in a DBMS indexed file	EXCPs to retrieve key (K) + EXCPs to retrieve record (R). Both numbers depend on DBMS used.	K = 3 R = 1
EXCPs required to add a new record to one master and two detail files	K + 1R + 2R (to add master) (to add detail)	6.
EXCPs required to update a record in master and two detail files. Note that a read and write is involved	K + 2R + 4R	9
EXCPs required to open file	F - depends on operating system and DBMS used.	3
EXCPs required to close file	C - depends on operating system and DBMS used.	3
Time required to perform one EXCP	Depends on hardware configuration	.032 seconds per EXCP

is made. The processing descriptions are taken from Exhibit B-1 and the parameters are taken from Exhibit B-2.

Step #1 Process Transaction (Batch)

In this step 40 transactions are read from a transaction file (blocking factor of 10). Processing a transaction involves updating the master file and adding one record apiece to the detail file. The pointers to the free areas in the detail files are stored in core.

Function	# of I/O Operations		
. Read program into memory	1	=	1
. Open four files	4x3	=	12
. Read Trans. File	40x1/10	=	4
. Update Master (K+2R	40x5	=	200
. Add to Detail (2R)	40x2	=	80
. Close four files	4x3	=	12
	TOTAL	=	309
	# of Times Per Year	x	365
	Annual # of EXCPs		112785

Step 2 Master File Listing

This step is performed once a day and involves passing the Master File sequentially (blocking factor 4, # of records = 500).

Function		# of I/O Operations
. Read Program into memory		1
. Open Master File		3
. Pass Master File	500x1/4 =	125
. Close File		3
	TOTAL	132
	# of Times Per Year	x365
	Annual # of EXCPs	48180

The total number of I/O operations (EXCPs) per year for the system should be calculated in this fashion. A "safety" factor, covering all miscellaneous or indeterminate I/O operations should be added. This factor can range from 10% - 50% and should be based on prior experience with systems of type proposed. More complex systems should employ higher contingency factors.

4. CALCULATE THE CPU REQUIREMENTS FOR EACH STEP

Both the COMNET and UNIVAC computing facilities include the amount of CPU seconds in their charging algorithms. Estimating CPU time is a difficult task but "guestimates" can be prepared by applying the following procedures:

- Categorize the steps by complexity of calculations involved
- Estimate the "CPU bound" percentage (i.e., CPU time/I/O time) of each step. This estimate is made by running benchmarks, or examining existing operational systems
- Calculate the I/O time for each step
- Apply the CPU factors to each step to determine CPU time
- Calculate the total annual CPU time

This calculation is illustrated for the two sample steps as follows:

Step #1 Process Transactions (Batch)

The total # of EXCPs required for this step is 309. Using 0.0372 seconds per EXCP, (this varies for different machines) this step requires 11.5 seconds of I/O time. Benchmarks and comparisons indicate that this step will be approximately 20% computer bound, resulting in 2.3 CPU seconds per step, or 840 CPU seconds per year.

Step #2 Master File Listing

This step requires 132 EXCPs or 4.9 seconds of I/O time. Benchmarks indicate that this type of step is 10% CPU bound, resultin in 0.49 CPU seconds per step, or 180 CPU seconds per year.

The total number of CPU seconds should be calculated in this manner. Again, 10% to 50% may be added to this estimate to allow for miscellaneous processing and errors in the estimates.

5. ESTIMATE OTHER HARDWARE RESOURCES REQUIRED

In this activity all other information necessary for calculating operating costs is gathered. Seven examples of miscellaneous charges that should be considered are as follows:

- On-line Storage. This can be determined by estimating the size of files and work areas required by the system. The information can be obtained from the needs analysis and the system design.
- Off-line Storage. This is the size of files that can be stored on mountable disk packs and tapes.
- Printer Costs. These charges are usually computed by the number of print lines, which can be obtained by estimating the size and frequency of all printed reports.
- Connect Time. There is often a flat rate between $15 and $30 an hour for on-line interactive operations. This should be calculated by estimating the annual number of hours required for data entry and text editing.
- Memory Size. Memory size is very dependent on how the system has been structured. Moreover, tradeoffs are always possible between EXCPs and memory size through overlay techniques. The best way of estimating memory allocation is by experience or by obtaining the advice of the appropriate technical support group.
- Telecommunications Charges. These charges can be computed from the hours of connect time and the number of print lines. In addition, the costs of modems and front end processors also should be included.
- Miscellaneous Charges. These are charges for tape or disk mounts, tape storage, or changing printer paper, and are usually a small percentage of the total system costs. In addition, the operating costs of other computer-related equipment should be included such as CRT terminals or communications equipment.

6. APPLY THE APPROPRIATE CHARGING ALGORITHM TO DETERMINE ANNUAL COMPUTER OPERATING COSTS

The most current charging algorithm for the appropriate computer center should be used in determining the annual operating charges. Whenever possible, the projected rates for the time frame when the system will be operational should be used. Exhibits B-3 through B-7, on the following five pages, show the current charging algorithms for the COMNET and UNIVAC facilities respectively.

7. CALCULATE ANNUAL PERSONNEL COSTS

The total amount of personnel time that is required per year should be calculated for at least four types of functions, as follows:

- Data entry and file maintenance activities
- Keypunching
- Operational data processing equipment, such as printers or minicomputers
- Verifying that printouts and databases are accurate

Exhibit B-3
U.S. ENVIRONMENTAL PROTECTION AGENCY
Current Charging Algorithm at COMNET

The primary charge at COMNET is for a CUU (Computer Utilization Unit), currently charged at $________.*

The formula for computing a CUU is

  2.967 x CPU seconds
+ 0.01177 x Total EXCPs
+ 0.002321 x Memory in Thousands
+ 0.005381 x Tape EXCPs
+ 0.03015 x Disk EXCPs

In addition there is a charge for the following items.

• Print lines	$__________*
• Storage space	$__________*
• Tapes	$__________*

In addition, factors are applied for priority.

Note * indicates that the charges have not been determined yet.

Exhibit B-4

U.S. ENVIRONMENTAL PROTECTION AGENCY
CURRENT CHARGING ALGORITHM AT NCC UNIVAC FACILITY

The charging algorithm is as follows:

(SRU's * D) + M

Where:

SRU's = (SUP Charges + Memory Charges) x Priority Weighting Factor
D = Dollar charges per SRU (currently $140)
M = Dollar charges for miscellaneous components

- SUP charges (Standard Units of Processing) are the sum of CPU usage, I/O usage and UNIVAC Executive Services. Exhibit B-5 on the following page shows the charges for the components of a SUP
- Memory charges are calculated by the formula shown in Exhibit B-6
- The calculation of the Priority Weighting factor is shown in Exhibit B-6
- The charges for miscellaneous components are shown in Exhibit B-7

Exhibit B-5

U.S. ENVIRONMENTAL PROTECTION AGENCY
Components of SUP Charges

SUP COMPONENT	SUP SUB-COMPONENT	UNIT OF MEASURE	DEMAND* CHARGE	BATCH* CHARGE
CAU USAGE		1 Memory Storage Reference	800 Nano-seconds	330 Nano-Seconds
I/O USAGE	Drums	100,000 words of Data Transferred	.82 seconds	.82 seconds
	8440 Discs	100,000 words of Data Transferred	.72 seconds	.72 seconds
	9 Track Tape	100,000 words of Data Transcribed	2.35 Secs/ 1600 bpi	.35 Secs/ 1600 bpi
	7 Track Tape	100,000 words of Data Transcribed	6.25 Seconds	6.25 Seconds
EXECUTIVE SERVICES (CC/ER) USAGE		ECL Control Card or Executive Request	Standard UNIVAC Charge	Standard UNIVAC Charge

* SUP Charges in seconds

Exhibit B-6
U.S. ENVIROMENTAL PROTECTION AGENCY
Calculation of Memory Charges and Priority Weighting

MEMORY CHARGE COMPONENT

The following formula describe the memory charges for demand and batch run steps.

Demand

```
     .00462*SUPS*SIZE
+    .000196*SUPS*(SIZE*20.992 + 85)
+    .000196*SUPS*(SIZE*20.992 + 85)*SIZE*.00462
```

which equals

```
     SUPS*(0.01666 + SIZE*(.0088114 + .0000190*SIZE))
```

PRIORITY WEIGHTING COMPONENT

This component weighs SUP and memory charges according to run priority and amount of SUP/Memory charges accrued by the run. Results of these computations are expressed in terms of Standard Resource Units (SRUs), as follows:

(Note that SM = SUP

BATCH PRIORITY	
Urgent	SRUs = 6 x SM
Preferred	SRUs = 2 x SM
Routine	SRUs = SM
Deferred	SRUs = 0.75 x SM
DEMAND	SRUs = 2.5 x SM

charges + memory charges, expressed in minutes)

Exhibit B-7
U.S. ENVIRONMENTAL PROTECTION AGENCY
Miscellaneous Charges

Following is a summary of the charges for miscellaneous components at the NCC UNIVAC facility.

- Mass-Storage
  - Temporary - No charge now
  - Fixed & Semi-fixed - $.025 per track/week
  - Tape mount - includes mount cost, plus proportion of subsystem for unit of time. - No charge now.
- Unit Record I/O - No charge now
- Demand Processing Session Length - No charge now
- Tape/Disk Storage
  - NCC tapes - $1.00/month
  - Disks - $12.00 per week (actual pack cost plus fee to mount disk)
  - Non-standard tapes
    - $2/day - day 1
    - $1/day - day 2-14
    - $2/day - day 15 and over
- Plotter Usage - No charge now
- Block Time - $1500 per clock hour
- Special Procurements, Consulting Fees, etc. - Actual cost

8. CALCULATE ANNUAL MAINTENANCE COSTS

Annual maintenance costs should be estimated for inclusion in the cash/flow analysis. There are four types of maintenance costs, as follows:

- Regularly scheduled software maintenance
- Minor system enhancements
- Error correction and debugging
- System performance tuning and improvement

Note that major system enhancements should not be included as maintenance costs. Instead, these enhancements should be cost justified on their own merit.

One rule of thumb that can be used to estimate maintenance costs is, as follows. For the first year of operation, maintenance costs will run about 10% to 12% of the one-time system programming and implementation costs, between 6% and 10% for the second year, and about 5% for each subsequent year for the life of the system.

APPENDIX C

GUIDELINES FOR PREPARING A PROJECT PLAN

The main purpose of preparing a project plan is to translate the list of resource requirements into an action plan which takes into account the various constraints to which a project is subject. As a result of the detailed analysis of development costs, the project planning process is begun with estimates of the amounts of resources which are needed for each task in the project. This Appendix discusses two techniques that are used in preparing project plans, as follows:

- Precedence networks or PERT charts
- GANTT charts

1. THE PREPARATION OF PRECEDENCE NETWORKS IS AN EFFECTIVE METHOD OF PLANNING FOR THE INTERDEPENDENCIES BETWEEN TASKS

There are four major benefits achieved through the use of precedence networks, as follows:

- Precedence networks provide direct visual determination of project interdependencies and interrelationships

- Precedence networks identify flexibility and inflexibility of task assignments
- Precedence networks provide the basis for critical path analysis
- Precedence networks suggest a plan for corrective action

There are five major steps in preparing a precedence network, as follows:

- Review the list of work products and tasks for this project
- Analyze the intrelationships and interdependencies among work products and activities
- Identify which of the work products and major activities need detailed precedence analysis and perform this analysis
- Construct the precedence networks
- Identify the critical path on the precedence network

(1) Review The List of Work Products and Tasks For The Project

During this step the project should be broken down into its component tasks, and the elapsed time necessary to complete each task should be identified.

(2) Analyze the Interrelationships and Interdependencies Among Work Products and Activities

In this step the project planner determines which work products and activities must precede or succeed others, and which can occur simultaneously. All of the tasks which must be completed before a given task begins should be identified so that any dependencies will be considered in developing the schedule.

(3) Identify Which of the Work Products and Activites Need Detailed Precedence Analysis and Perform This Analysis

Some work products or activities may be composed of tasks that either can be executed concurrently or have dependencies so obvious that a network would be superfluous. Nonetheless, most activities should be subjected to the same analysis process at the task level. Tasks are defined as activities of not more than 80 hours in duration.

(4) Construct the Precedence Network

A precedence network is constructued to provide a visual representation of the interdependencies between tasks.

Dependencies are shown from left to right, as depicted in Exhibit C-1 following this page. Tasks which are not dependent on any other task are identified in circles and are connected to the start point with a solid line. Tasks which are dependent on some previous task then are entered and connected with a solid line to the tasks on which they are dependent. The process should be continued until all the tasks have been entered in the network and are connected to the end of the project.

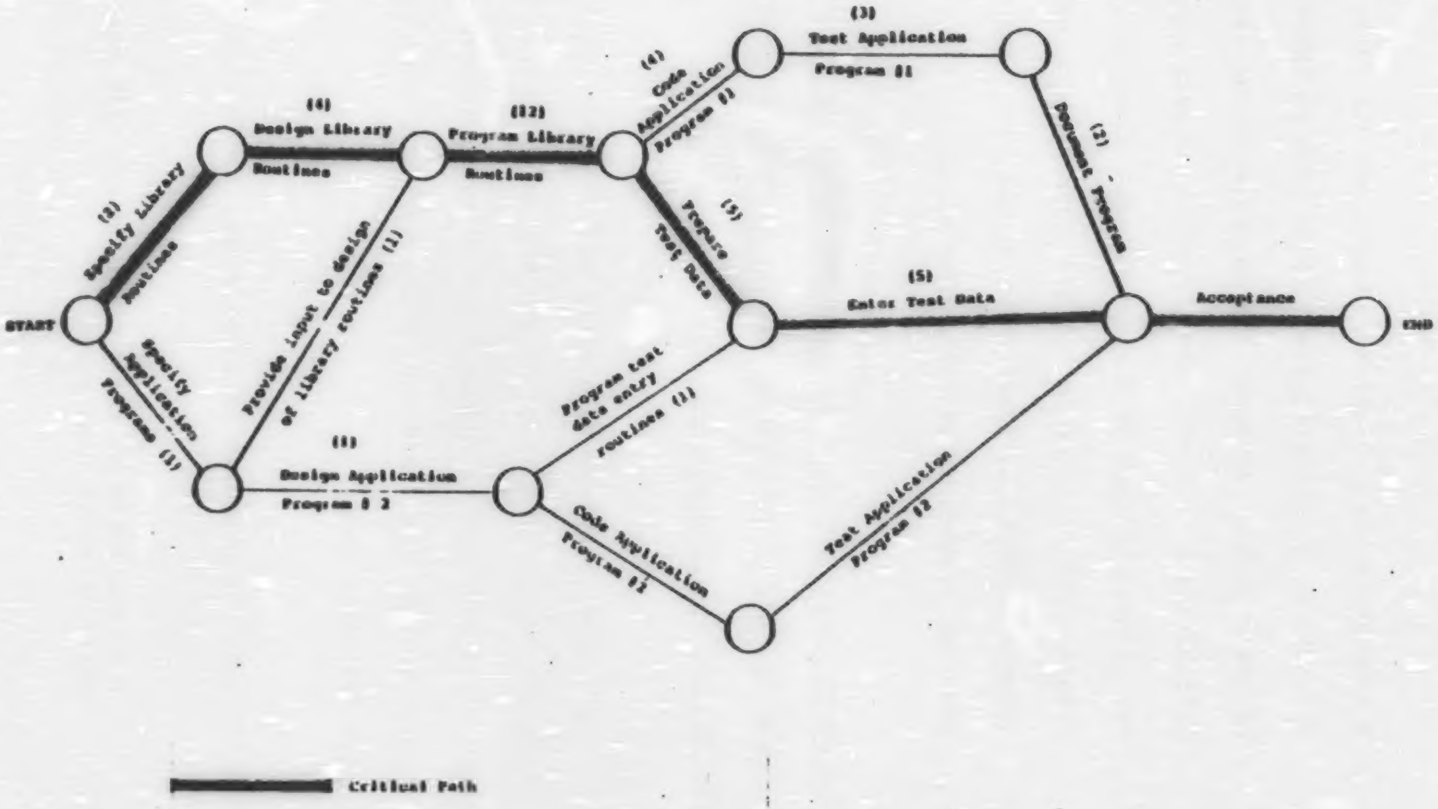
The elapsed time estimates for each task then should be entered on the solid lines preceding the circle representing each task.

(5) Identify The Critical Path On The Precedence Network

A colored pen should be used to trace the path of interdependent tasks that represent the longest amount of time from the start to the completion of the project. This highlights those tasks that are most sensitive to start and completion dates. The completion time for paths which take less time than the critical path, is referred to as "float".

Exhibit C-1

U.S. ENVIRONMENTAL PROTECTION AGENCY
Sample Precedence Network


START
(2) Specify Library Routines
Specify Application Programs (1)
(4) Design Library Routines
Provide input to design of library routines (1)
(8) Design Application Program # 2
(12) Program Library Routines
(4) Code Application Program #1
(5) Prepare Test Data
Program test data entry routines (1)
Code Application Program #2
(3) Test Application Program #1
(5) Enter Test Data
Test Application Program #2
(2) Document Program
Acceptance
END
Critical Path

A completion date should be established for tasks on the critical path by adding the elapsed time to the starting date of the project. Although the schedule of the dates along the critical path is fixed, the non-critical path completion dates may be maniplulated to the extent that there is float, so as to evenly distribute the use of the various resources. The next technique, known as GANTT chart preparation, can be used to show the allocation of tasks over time.

2. THE GANTT CHART TECHNIQUE COMBINES THE RESULT OF THE PRECEDENCE NETWORK TO PRODUCE AN OVERALL PROJECT SCHEDULE AND WORK ASSIGNMENTS FOR THE PROJECT TEAM MEMBERS

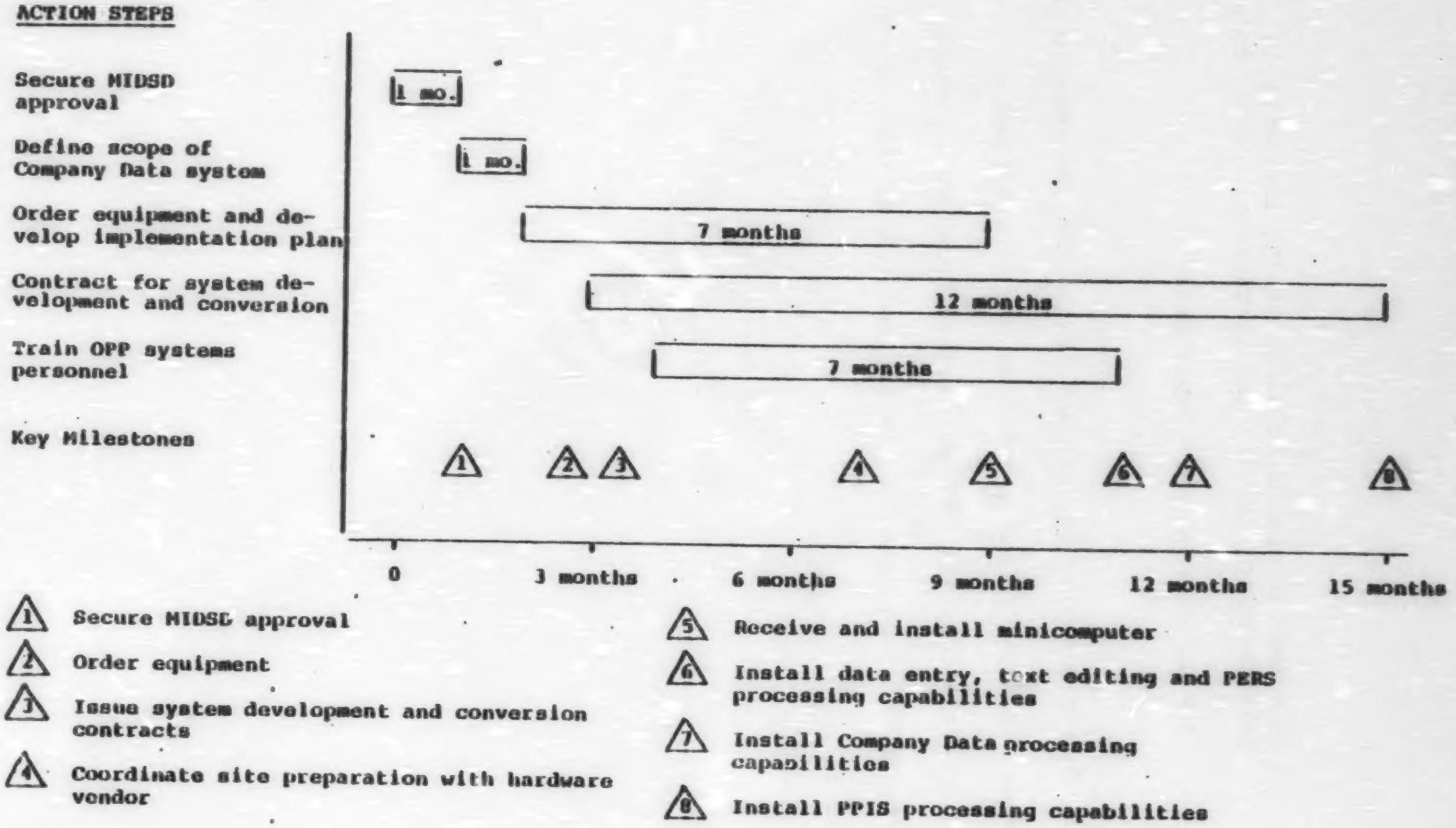
The GANTT chart consists of a scale divided into units of time across the top and a listing of project activities on the left hand side. Bars are used to indicate the schedule of each activity in relation to the time scale. A sample chart is shown in Exhibit C-2 on the following page

A GANTT chart is prepared in three steps, as follows:

- List the tasks of the project on the left hand side of the chart in start time sequence

Exhibit C-2

U.S. ENVIRONMENTAL PROTECTION AGENCY
Sample GANTT Chart



- Draw bars on the chart illustrating the schedule taking into consideration staffing and precedence network constraints
- Show milestones where applicable

GANTT charts are easy to read and update and can show progress to date at a glance. However, they do not give a complete picture of the interrelationships between tasks. Thus, it is useful for GANTT charts to be prepared after the preparation of the precedence network.

APPENDIX D

GUIDELINES FOR PREPARING A CASH FLOW ANALYSIS

Cash flow analyses are prepared to provide management with a measure of the value of each alternative. The discounted cumulative savings of each alternative in its last year of operation constitute the value of each proposal. Exhibit D-1, on the following page shows a sample cash flow analysis.

For a typical cash flow analysis, development costs are broken down into personnel costs and machine costs and are shown in the years in which they are incurred. Operating costs are shown in the years that they are incurred, broken down by personnel and machine charges. Operating costs usually increase at the inflation rate. Operating costs include maintenance costs and the cost of managing and operating the system. Maintenance costs are included also in the operating costs.

The last year of operation is the point at which the system becomes obsolete and should be replaced. Enhancements and other types of

Exhibit D-1
U.S. ENVIRONMENTAL PROTECTION AGENCY
Sample Cash Flow Analysis

ALTERNATIVE #1 ($000)

	Year N	Year N+1	Year N+2	Year N+3	Year N+4	Year N+5
DEVELOPMENT COSTS						
- Personnel	100	75	25			
- Machine	20	15	5			
OPERATING COSTS						
- Personnel			15	17	19	21
- Machine			25	27	30	33
TOTAL COSTS	120	90	70	44	49	54
QUANTIFIABLE BENEFITS	0	0	50	120	120	120
NON-QUANTIFIABLE BENEFITS	0	0	70	140	160	180
NET SAVINGS	(120)	(90)	50	116	231	246
PRESENT VALUE FACTORS (10% Discount Rate)	1.00	0.91	0.83	0.75	0.68	0.62
DISCOUNTED SAVINGS	(120)	(82)	42	87	157	153
TOTAL PRESENT VALUE ("Value" of Alternative)	237					

maintenance which do not affect the original system drastically should not be considered as affecting the life of the system. The last year of operation should be calculated by considering four factors, as follows:

- Anticipated changes in functional requirements
- Anticipated changes in government regulations
- The hardware and software used
- Short and long term data processing plans of the Program Office

The next line in the cash flow analysis summarizes the total cost of the system for each year of usage.

Benefits that are derived from implementation of the system are shown in the years that they are incurred. Note that benefits should include the costs of operating the current system since these costs will not be incurred once the new system has been implemented.

Intangible benefits shown on the next line, represent the value of benefits which are not quantifiable but which can be allocated a dollar value. The source of these benefits and the method used to derive them are stated in the feasibility study report.

The next line shows the present value factors that are used to discount the cash flow. The formula used is based on the interest rate that is currently in use. The discount value that is recommended to be used by GSA is 10%. Exhibit D-2, on the following page shows a table of present value factors to be used for a range of discount rates.

The savings line is multiplied by the present value factors to arrive at the discounted savings line. These are then summed to come up with total discounted present value of the alternative. This value figure should be compared with the corresponding value of the other alternatives when preparing the economic evaluation of alternatives.

Exhibit D-2

U.S. ENVIRONMENTAL PROTECTION AGENCY
Table of Present Value Factors

DISCOUNT RATE

YEAR	1%	2%	4%	6%	8%	10%	12%	14%	15%	16%	18%	20%
1	0.990	0.980	0.962	0.943	0.926	0.909	0.893	0.877	0.870	0.862	0.847	0.833
2	0.980	0.961	0.925	0.890	0.857	0.826	0.797	0.769	0.756	0.743	0.718	0.694
3	0.971	0.942	0.889	0.840	0.794	0.751	0.712	0.675	0.658	0.641	0.609	0.579
4	0.961	0.924	0.855	0.792	0.735	0.683	0.636	0.592	0.572	0.552	0.516	0.482
5	0.951	0.906	0.822	0.747	0.681	0.621	0.567	0.519	0.497	0.476	0.437	0.402
6	0.942	0.888	0.790	0.705	0.630	0.564	0.507	0.456	0.432	0.410	0.370	0.335
7	0.933	0.871	0.760	0.665	0.583	0.513	0.452	0.400	0.376	0.354	0.314	0.279
8	0.923	0.853	0.731	0.627	0.540	0.467	0.404	0.351	0.327	0.305	0.266	0.233
9	0.914	0.837	0.703	0.592	0.500	0.424	0.361	0.308	0.284	0.263	0.225	0.194
10	0.905	0.820	0.676	0.558	0.463	0.386	0.322	0.270	0.247	0.227	0.191	0.162

APPENDIX E

PHASES AND TASKS IN THE LIFE OF AN ADP PROJECT

There are four major phases in the development of a data processing system, as follows:

- The Feasibility Study Phase
- The Detailed Specifications and Program Design Phase
- The Programming and Testing Phase
- The Conversion and Installation Phase

These phases are described in detail in this section in order to provide a complete checklist of tasks to be used in preparing cost estimates and schedules during the feasibility study.

1. THE FIRST PHASE OF THE PROJECT LIFE CYCLE IS THE FEASIBILITY STUDY

A feasibility study is initiated once the problem, opportunity, or user requirement has been identified. The purpose of the feasibility study is to define the problem or user requirement in greater detail, identify alternative solutions and make a recommendation for further study and detailed design. The nine major steps of a feasibility study have been defined in detail in the main body of this report, as follows:

- Determine user needs and define the objectives and functional requirements of the proposed system
- Analyze the current operational environment
- Prepare evaluation criteria
- Develop alternative solutions
- Evaluate alternative solutions
- Develop recommendations and review with management
- Perform the initial system design
- Prepare detailed economic analysis for the proposed alternative
- Prepare user acceptance criteria and project plan

At the end of the feasibility study a decision is made whether or not to continue the project into the detailed design phase. The feasibility study typically requires five to tan percent of the total project costs and can take up to fifteen weeks or more to complete. The level of effort is dependent on the size and complexity of the problem and the extent of jusitification required before proceeding to the next step.

2. THE SECOND PHASE OF THE PROJECT LIFE CYCLE IS THE DETAILED DESIGN AND SPECIFICATIONS PHASE

The primary purpose of the detailed specifications phase is to receive user signoff on precisely what the proposed system is intended to do. It is the foundation for all program implementation. The design should be of sufficient detail that functional issues are resolved. There are twelve major tasks in the detailed specifications phases, as follows:

- Plan and organize the phase
- Prepare a statement of design philosophy
- Define all input functions
- Define all output functions
- Define edit and validation logic
- Define file layouts
- Define processing specifications
- Finalize system design and analyze performance
- Prepare cross references lists and index
- Revise economic evaluation
- Prepare conversion specifications
- Review

The steps in the detailed design phase are described as follows:

(1) Plan and Organize This Phase

In this step a project plan is prepared and startup activities are performed. This step consists of seven activities, as follows:

- Assemble project team
- Make available to members the necessary documentation to date, including:
    - The project plan
    - The feasibility study
    - The hardware specifications
    - Project reporting and tracking procedures
- Conduct an orientation meeting to discuss the following:
    - Review the scope, objectives and constraints of the phase
    - Review the overall project schedule
    - Review the design phase schedule with special emphasis on interdependencies in parallel phases
    - Discuss the work performed to date
    - Review personnel work schedules
    - Establish weekly client meetings
- Develop design standards
- Develop any change control procedures
- Discuss general design goals, such as:
    - Simplicity
    - Flexibility
    - Ease of maintenance
    - Ease of operation by the user
    - Operational considerations with special emphasis given to backup and recovery procedures

- Emphasize the key concepts defined in the feasibility study, such as:
    - Scope of system
    - Response time and turnaround time requirements
    - System loading and growth
    - System life expectancy
    - Development schedules and budget

(2) Prepare A Statment of General Design Philosophy

In this step a brief discussion is prepared of design goals and the reasons for their selection. Nine topics are addressed as follows:

- Criteria for overall system optimization
- General file structure
- Program design rules
- Design considerations that are influenced by the hardware selection
- Internal and external contols
- Security considerations
- Auditing considerations
- Backup and restart considerations
- Maintenance and enhancement considerations

(3) Define All Input Functions

In this step input functions are designed and documented in detail in four activities, as follows:

- Complete input forms design
- Define the input procedures and workflow
- Define any pre-computer process controls
- Review with user

(4) Define All Outputs

In this step all outputs are defined and finalized, in five activities, as follows:

- Complete the layout of all outputs
- Define each field on every report
- Prepare report descriptions for each report including:
  - Source of data
  - Destination of report
  - Expected volumes
- Define post-computer processing and controls
- Review with user

(5) Define Edit and Validation Logic

In this step the validation tests and error conditions for each input function are documented. In addition each input function is checked to be sure that there is a corresponding input for each field on the outputs.

(6) Define File Layouts

In this step the files of the system are designed. Eight types of information should be included for each file, as follows:

- A brief description of the purpose of the file
- The organization sequence and keys of the file
- The access method and relationship to other files
- Volume requirements
- Information on when the file is created, deleted and updated
- Record and field layouts including relative position, size and storage type
- Name and description of each field including valid values
- Backup requirements

(7) Define Processing Specifications

This step consists of three activities, as follows:

- Complete the detailed definition of each processing function in the system, including:
  - Conditions to be tested
  - Special calculations to be performed
  - Definition of error conditions
- Describe all controls
  - Computer processing controls
  - Audit trails
  - Security and error recovery
- Perform reviews with users and other technical personnel

(8) Finalize System Design and Analyze Performance

In this step the system flow chart is prepared and estimates are prepared for ten performance related issues, as follows:

- File sizes
- Average access time
- Frequencey of file accesses
- Program sizes
- Potential bottlenecks

- High usage areas
- Frequency of change
- Growth rate anticipated
- Core storage requirements
- Line and terminal requirements

(9) Prepare Cross-references, Lists and Indices

This step consists of consolidating information by preparing:

- A list of all files
- A list of all programs
- A list of data elements
- Indices showing interrelationships:
  - Among all data elements
  - Among files
  - Among programs

(10) Revise Economic Evaluation

In this step the cost/benefit analyses that were prepared at the end of the feasibility study are reviewed and updated as necessary. Any changes since the feasibility study are documented, and budget approval is secured for all expenditures. The final cost figures are those against which the development effort and the eventual production system will be measured.

(11) Prepare Conversion Specifications

In this step the procedures necessary to start up the complete system in its operational environment are defined. Six tasks are performed, as follows:

- Analyze the data base
- Identify sources of data, including
  - Paper files
  - Notebooks
  - Machine readable data sources
- Define conversion procedures
- Define verification controls, including
  - Automatic checking
  - Manual checking
- Define special conditions for parallel test
- Define conversion schedules including starting and ending dates for all activities

(12) Perform Final Review With User

In this step the final review is held with the users and user sign-off is received on the functional specifications.

The functional specifications should cost approximately 20% of the overall budget. At this point in the project life cycle about 30% of the total overall project budget usually has been expended.

3. THE THIRD PHASE IN THE PROJECT CYCLE IS THE PROGRAM DESIGN, PROGRAMMING AND TESTING PHASE

There are nine steps in programming and implementation phase of the project cycle, as follows:

- Prepare project plan for this phase
- Prepare program specifications
- Prepare test specifications
- Establish library and backup procedures
- Program common routines
- Code programs

- Compile program documentation
- Plan next phase
- Review

These twelve steps are described briefly, as follows:

(1) Prepare A Project Plan for This Phase

In this step schedules and budgets are reviewed with user and management personnel. Staff assignments are made and a work plan is confirmed. Project reporting and tracking mechanisms are established.

(2) Prepare Program Specifications

Program specifications are a detailed description of each program module. Four tasks are performed, as follows:

- Prepare a description for each program
- Prepare a single page flowchart showing the main program logic, including:
  - How the program is called
  - Interface to other programs
  - Main logic flow
  - General routines referenced

- Prepare an I/O diagram showing all files accessed by this program
- Describe any unusual procedures or techniques involved.

(3) Prepare Test Specifications

In this step the programmer specifies how his program will be checked. All branches, and data ranges should be tested as well as all conditional and abnormal situations. The testing philosophy, general procedures, and success criteria for each test should be described.

(4) Establish Library and Backup Procedures

Six activities are performed in this task, as follows:

- Identify library files
- Define general or application specific routines available in the library
- Define specific coding standards for general routines
- Identify library controls
- Define procedures for modifying library routine
- Establish backup procedures including:
  - Backup medium
  - Backup schedule

  - Backup responsibilities
  - Storage location and organization
  - Frequency and number of backups

(5) Program Common Routines

Common routines and system programs are coded before any of the application programs. Seven examples of common routines include:

- Report generation routines
- Data/time conversion routines
- Input parsers
- Access routines
- Special functions
- Skeletons for similar types of processing
- Program debugging and tools including:
  - Loaders
  - Dumps
  - Utilities for creating and displaying data
  - Debug facilities

(6) Code Programs

In this step individual programs are coded according to the program standards and coding conventions, utilizing library and common routines where possible. Programs then are tested according to the unit test specification that have been defined for each program.

(7) Compile Program Documentation

In this step five types of program documentation are produced for each program, as follows:

- Commented program listing
- Cross references for symbols
- Program object code
- Program source code
- The results of the testing procedure

(8) Plan Next Phase

In this step the detailed schedule is laid out for the integration and systems test phase.

(9) Review

This step consists of three review tasks, as follows:

- A review of design and unit test specifications
- Individual reviews for each program, including code reviews, structured walk through and review of test cases
- A management review at the end of all programming

At this point the third phase of the development cycle has been completed. This phase usually costs about 30% to 35% of the overall budget. Thus approximately 70% of the budget usually is spent by this point.

4. THE LAST PHASE OF THE PROJECT CYCLE IS THE SYSTEM INSTALLATION PHASE

This phase consists of six steps as follows:

- Plan this phase
- Prepare user manuals
- Prepare system manager's guide

- Conduct integration test
- Complete conversion
- Conduct post-implementation review

(1) Plan Phase

In this step the plan for the integration test and conversion should be finalized.

(2) Prepare User Manual

The user manual should describe the procedures necessary for successful operation of the system, including six sections, as follows:

- A functional overview of the system
- Input descriptions, showing input forms and rules for inputting the data
- Operating procedures, including data entry instructions and error correction
- Output procedures, including descriptions of the output and rules for checking and distribution of the output
- Special processing including file correction, system audits, and end-of-month and end-of-year processing
- Terminal usage instructions

(3) Prepare System Manager's Manual

The system managers manual provides the necessary information to enable technical personnel to operate the system. Included are run descriptions, flow diagrams, job control requirements, instructions for controlling and distributing system outputs and backup restart procedures. It usually consists of at least four sections, as follows:

- Overview
- Computer run procedures
    - Run schedules
    - Run flowcharts
    - Run descriptions
    - Backup restart procedures
    - Computer operating instructions
- Exceptional conditions
    - Error messages
    - Error recovery procedures
- Hardware description
    - Central processor
    - Consoles
    - Terminals
    - Printers
    - Storage devices
    - Communications devices

(4) Conduct Integration Test

The integration test consists of four activities, as follows:

- Prepare for test
  - Review test plans and success criteria
  - Insure hardware/software availability
  - Insure all programs to be tested are released
  - Insure all special programs needed are available
- Create data base as specified by test plan
- Conduct tests
  - Read applicable user documentation
  - Perform tests
  - Check errors
  - Identify areas of inefficiency
  - Identify user documentation errors
  - Reject or accept programs and user documentation where necessary
- Review results

(5) Complete Conversion

This step consists of six activities, as follows:

- Train conversion team
- Define data that must be gathered manually

- Balance data for control purposes
- Run conversion cycles
- Maintain converted data until the system is operational

(6) Conduct Post-implementation Review

This step consists of five activities, as follows:

- Review documentation including:
  - Program documentation
  - User manuals
  - System managers manuals
- Analyze whether or not the system has met objectives or not.
- Analyze whether or not the system has attained the economic objectives
- Identify improvement opportunities
- Prepare review report for management